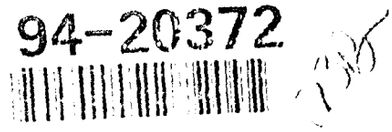
GUIDEBOOK FOR RISK PERCEPTION AND COMMUNICATION IN WATER RESOURCES PLANNING

Part II

- An Annotated Bibliography -



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Guidebook for Risk Perception and Communication in Water Resources Planning

Part II – An Annotated Bibliography

A Report Submitted to the

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PREFACE

This annotated bibliography addresses the water resource planner's need for comprehensive planning guides where risk is an integral factor in the decision process. The Economic and Environmental Guidelines for Water and Related Land Resources Implemented Studies prescribed by the Water Resource Council recognize that risk and uncertainty are inherent in water resources planning. Corps planners must prepare to evaluate risk behavior and the associated perceptions of risk. There also exists a great need for opening a two way avenue of communication between the public and the planners/operators of water resource projects. This report contains PART II of the larger work titled Guidebook For Risk Perception and Communication in Water Resources Planning. PART I presents the underlying principles and guidelines for consideration in the Corps planning process.

The purpose of this volume (PART II) is to provide water resource managers with a survey of current and relevant literature on risk and uncertainty management and communication. This volume consists of a detailed annotation of 129 journal articles, books, theses, dissertations, or research reports that have been numbered and cross-referenced to match principal themes associated with risk perception, behavior and risk communication. Furthermore, the annotations are grouped by planning areas in which Corps planners are most likely to be involved. Additional literature entries pertaining to the general body of risk and uncertainty evaluation and field experience are provided in the appendices. Risk literature is quite extensive and a full compendium of citations is beyond the scope of this project. Corps planners are encouraged to supplement this listing by adding references which they personally review and find suitable.

We wish to acknowledge the suggestions and guidance provided by Duane D. Baumann, John Sims, and Clifford Russell in the preparation of this volume. We would also like to recognize the capable support staff of Planning and Management Consultants, Ltd., without whom the completion of this study would not have been possible. The staff includes: Linda Cox, Russell Hinckley, Judith E. McFarlin, and Jennifer Sala.

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1

Albertson, M. L., Poreh, M., & Hurst, G. A. (1978). Big Thompson flood damage was severe, but some could have been prevented. Civil Engineering, 48(2), 74-77.

Key Words: Flood control, all planning steps.

Damages from the 1976 Big Thompson flood were confined largely to three distinct areas: the Narrows upstream from the canyon mouth, the floodplains upstream from the Narrows, and the area downstream from the canyon mouth. Damages to roadways, buildings, and other structures were severe. Damages resulted not only from the flow of the river but also from boulders, rocks, trees, vehicles, houses, sediment, and other debris being washed into the river. Most of the houses that were washed away either did not have adequate foundations or were not anchored to the foundation. An inverted siphon across the river at the mouth of the canyon collapsed due to the loss of an unanchored pier. Erosion and scour caused extensive damage to roadways, foundations, and structural piers. Rock slopes and riprap installed to protect against normal flooding conditions could not withstand the extreme flows which resulted in severe scouring, except in one case where rock had been hand-placed into a smooth, interlocking pattern offering little resistance to the river flow. In the Narrows, nearly the entire roadway was washed away. The diversion and storage dam for a hydropower plant several miles upstream failed because scour at the north end caused undermining and eventual collapse. The dams surviving at the end of the Narrows were masonry arch dams that permitted the free flow of water over them. Damage was most severe at the mouth of the canyon; the Bureau of Reclamation Colorado-Big Thompson water project lost all ability to place water into or across the Big Thompson River. A list of damages and of emergency operation procedures initiated by the Bureau of Reclamation is given.

During the first week after the flood, recovery efforts included a survey of damage to federal and private water and power facilities and the preparation of a power system contingency plan. Full power service was maintained to nearly 100 preference power customers throughout the crisis, and full supplemental water service was restored to about 200,000 irrigated acres and to many municipalities along the river without crop damage or serious water shortages occurring. Steps to minimize future flooding damage include preventing floodplain development, anchoring existing structures to massive foundations, using reinforcing steel whenever concrete blocks are used, and protecting highway embankments from the destructive forces of floodwaters by installing properly constructed riprap or by anchoring retaining walls to canyon walls. The author acknowledges the expense required for such protection but advocates the comparison of protective measure costs against the costs of rerouting the entire highway away from the flood zone. A flood warning system that can operate during power and telephone failures is of great importance; many lives could be saved by such a system although it would do little to reduce property losses.

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Allison, R. C., Durand, R., & Schwebach, G. (1988). Risk: A key water policy issue. Journal Water Pollution Control Federation, 60, 1211-1213.

Key Words: Water supply and planning, risk management, water contamination, drinking water, water for recreational use, reclaimed wastewater for irrigation, all planning steps.

This article presents risk management issues and particular points of debate concerning 1) drinking water; 2) marine and freshwater used for recreation; 3) reclaimed water or wastewater used for irrigation. The authors propose the development and implementation of a "policy for error variance" for handling risk and uncertainty related to drinking water and water for recreational use. The authors also suggest that decision makers utilize a "computational strategy" in the development of standards for reclaimed wastewater for irrigation since recent studies have demonstrated increased certainty regarding the causes and effects related to health hazards.

Water management and risk management related to water will become be primary topics of debate as safe and sufficient water supplies decrease. Currently, officials agree upon the importance of maintaining safe drinking water and water for recreational use. There is disagreement concerning the cost to be incurred in order to reduce the potential hazards related to wastewater used for irrigation. While additional research is needed to develop appropriate safety standards, strategies must be developed to handle these risks and uncertainties in the short run.

To handle these problems, risk managers should adopt a "policy for error variance." This policy would include alternatives for handling uncertain or unpredictable events. Examples of events involving weather and fire are presented: 1) when it rains, umbrellas and wipers are utilized to handle the effects of rain; 2) smoke detectors and fire departments are designed to minimize the effects of fire. Furthermore, flexible risk management guidelines are preferable to strict regulations and policies. The error variance policy would utilize probabilistic models with minimum risk or maximum benefit criteria. The authors assert that similar models are currently used for risk related decisions ranging from national defense to Indian health care.

Finally, decision makers face challenges as they manage safe and sufficient supplies of water for drinking, recreation, and irrigation. Until future research eliminates some of the uncertainty, disagreement and uncertainty concerning safety standards will continue to cause increased difficulties for managers. As a result, the authors propose utilization of "error variance policies" which use probability models for situations with great uncertainty, while regular "computational strategies" can be used in areas where research has been able to disperse some of the uncertainty and disagreement concerning safety standards.

This article may be useful for water planners as they consider various water supply sources and the relative costs and benefits. Water planners may also find the discussion of risk management useful in the development of their own risk management policies.

3

Appelbaum, R. P. (1977). The future is made, not predicted: Technocratic planners vs. public interests. Society, 14, 49-53.

Key Words: Decision makers' attitudes toward risk, all planning areas, all planning steps.

This article discusses the ideological distortion that society's problems are supposed to be solved by only "impartial" technical experts, rather than by a combination of experts, politicians and ordinary citizens. The author presents two arguments criticizing current procedures utilized in decision making processes. First, the author argues that the nature of social scientific knowledge limits the potential of experts. Then the author argues that society must revise its "theory of knowledge" and better define the differences between technical knowledge and political choices, in short "repoliticize our lives."

First, the author presents limitations of the social sciences. The social sciences mimic the natural sciences; acceptability or creditability of a study is directly related to the quality/sophistication of the mathematical techniques. However, unlike the natural sciences, the social sciences lack an adequate theoretical basis. Uncertainty exists, but technical experts continue to study problems with political elements, then these studies are used to justify decisions.

In the second argument, the author asserts that ordinary citizens have relinquished power to technical experts who are hired to analyze problems. Experts prescribe solutions to problems as diverse as, waging war, nuclear energy, school integration, and urban growth. While these problems may possess certain technical aspects, they are also highly political. As a result, technical experts alone should not propose solutions to these problems. However, society's reliance upon technical experts, and the inadequate theoretical foundation of the social sciences hinders improvement of the current process.

Planning studies should be simple and open. Social systems are open systems, therefore, all relevant facts/variables cannot be known. As a result, planners make assumptions. Most planning occurs despite the lack of accurate and complete data, resulting in escalated errors and miscalculations as the data is used as a basis for related studies and decision-making.

To avoid these problems, the technical experts need to be somewhat "deprofessionalized" so the general public may gain the confidence and skills required to understand and gain some control over the forces which impact their lives. After developing adequate understanding and confidence, the public may find decisions that were once apparently made for "the public good" actually may have been made for private interest. Special knowledge should be available through non-elite groups. This may be accomplished with the development of a large information base designed for use by ordinary citizens and community groups as well as broad public involvement in the planning process. The author also proposes the elimination of the idea that the future may be predicted. He suggests the use of a scenario-type format with various scenarios reflecting valid options. It is also important to develop scenarios reflecting the interests of non-elite groups as well.

4

Baecher, G. B., Paté, M. E., & Neufville, R. D. (1980). Risk of dam failure in benefit-cost analysis. Water Resources Research, 16(3), 449-456.

Key Words: Dam safety, decision makers' attitudes toward risk, all planning steps, analytical methods.

This article presents a procedure for estimating the costs of dam failure and for incorporating these costs into the total estimated cost of a dam project. Since current research does not offer an accurate estimate of the probability of dam failure, the authors propose the use of an assumed value based on existing data. A method of estimating risk cost based on calculation of comparative measures of human risk incurred for financial benefit is also proposed. The authors also address the question of whether or not risk costs should be included in the evaluation of total project cost and engineers perception and treatment of risk.

The risk cost is based upon expectation of failure of the dam structure. This probability of dam failure was estimated, using available data, to be 10^{-4} per dam year.

Risk cost is also determined by analysis of the severity of the consequences of failure. In estimating risk costs of dam failure, these authors suggest separating dollar and life accounts. In this way, a dollar value does not have to be assigned to life and estimates can be made on a cost-per-life-saved and/or cost-per-life-exposed basis. These estimates can then be compared with other activities in the public sector.

Using the risk-benefit factor α as a determinant tool, there may be instances where risk costs need not be included in the cost evaluation. For example consider construction of a dam costing $500 million of total project cost with an estimated annual benefit of $50 million and a design life of 50 years. If the costs of failure are about $2 billion, the risk-benefit factor (with a probability of failure of 10^{-4}) is less than one half of 1 percent. In this case the risk benefit factor is less than the margin of error in estimates of the benefits themselves and, therefore, risk should not be included in the analysis.

Some engineers view their role as guaranteeing public safety and others view their role as balancing risks. The civil engineering profession traditionally views its role as guaranteeing public safety. This view may be confirmed through the low probability of risks in civil works as compared to higher risks associated with other engineering activities such as automotive transportation and industrial accidents. However, dams do fail and risk of failure must be balanced against the costs of reducing the risk.

While the authors assert that the procedure for incorporating the risk costs into the evaluation of dams is straightforward and conventional from a theoretical point of view, they recognize the presence of several barriers to the adoption of such a procedure. Obviously, advocates of new projects are adverse to additional costs and many decision makers involved in dam construction are "extremely reluctant" to publicly admit that dams fail. Still, the authors argue for the utilization of this procedure, since dams do fail incurring significant costs.

5

Baird, B. (1986). Tolerance for environmental health risks: The influence of knowledge, benefits, voluntariness, and environmental attitudes. Risk Analysis, 6(4), 425-435.

Key Words: Public perceptions of risk, public behavior under risk.

This study was conducted to examine factors effecting risk estimates and tolerance levels among persons directly exposed to environmental health risks. This study was conducted by analyzing responses to a questionnaire given in Tacoma, Washington concerning a local copper smelter that emits arsenic. Extracts of the survey instrument and specific correlation matrices are included in the article.

The results of this study can be summarized in three major findings: 1) the strongest determinant of tolerance was the length of residency; 2) the respondents often performed their own benefit cost analysis as the basis of their tolerance; 3) contrary to intuitive belief neither a respondents proximity to the source nor knowledge of the subject were found to have a strong influence on either risk tolerance or informal risk estimates.

6

Begum, H., & Ahmed, E. (1986). Individual risk taking and risky shift as a function of cooperation-competition proneness of subjects. Psychological Studies, 31(1), 21-25.

Key Words: Public perceptions of risk, public behavior under risk.

This study was conducted to observe risk-taking proneness in individual and group situations as a function of cooperation-competition attitudes, behavior and sexual gender.

This study was conducted by issuing to each student a test to determine the cooperativeness-competitiveness of each student. Then each student was given a questionnaire to fill out, making choices based upon risks. Then the students were placed into groups of three and asked to render a group decision on the same questions as the questionnaire before.

In this study it was determined that: 1) Competition prone persons will take higher risks in an individual situation; 2) Male subjects were found to take higher risks in an individual situation; 3) Groups composed of competition prone persons showed a greater risky shift; 4) Groups composed of all males had a greater risky shift.

7

Benjamin, S. L., & Belluck, D. A. (1990). Risk feedback: An important step in risk communication. Water Network News, 82(11), 50-55.

Key Words: Public perceptions of risk, risk communication, risk feedback, all planning areas, all planning steps.

The authors discuss the importance of risk communication, risk feedback and its planning, how public perceptions influence risk communication, and problems encountered in risk communication. A case study which utilized risk feedback is presented as an example of how risk feedback can minimize conflicts between risk managers and the public.

Increasing public apprehension regarding concerns for health and safety as well as changes in government regulations regarding toxins in the air, water and food, has contributed to the increased interest in risk communication. The public wants and expects to be informed of risks. Officials need to learn how to communicate effectively with the public regarding risks, as well as how to incorporate the public into the decision making process regarding the management of risks.

Risk feedback involves: 1) the development of a plan including goals for each step of the decision making process; 2) continuous evaluation of public input in relation to the goals of each step; 3) work with the public so their input may be appropriately integrated with the goals; 4) facilitate teamwork, encourage people to clearly communicate their ideas; 5) select feedback techniques (small group discussions, interviews, and note media information such as letters to the editor) and make a strong effort to obtain feedback. Initiation of risk feedback programs may allow risk managers to avoid conflicts with the public. As demonstrated through the case study in this article, even though water utilities may be operating within the law, public outcry and protest may force utilities to change their operating procedures.

Effective risk communication and risk feedback programs can improve relations between officials and the general public. Dialogue among competing interest groups may also be improved. This increased communication aids in the prevention of conflict and improves the decision making process on issues related to environmental and public health risks. Use of risk feedback techniques can result in citizens embracing the remediation solution because they were an integral part of option solution.

8

Bowers, R. (1989) Safer dams. Civil Engineering, 59(9), 61-64.

Key Words: Dam safety, dam rehabilitation, all planning steps.

After two tragic dam failures in the 1970's, (164 deaths and $50 million of damage) heightened concern prompted Congress to authorize the U. S. Army Corps of Engineers to

administer a two phase dam safety program. A total of 8,000, high hazard dams throughout the United States were inspected, and classified as high hazard because of their proximity to populated areas. This paper focuses on problems related to earth dams, their common deficiencies and structural improvements. Case histories of: 1) Canoe Brook Reservoir in New Jersey; 2) Wanaque Reservoir; 3) Ada Dam; and 4) Williams Bridge Dam are also addressed in this article.

Phase I of the program involved the actual inspection of the dams. Phase II, administered by state agencies, involves an evaluation of subsurface, hydrologic, hydraulic and stability conditions. These findings can lead to the design of subsequent rehabilitation projects.

Common dam deficiencies fall into two groups, earth embankment problems and spillway/outlet problems. Three embankment problems are common: 1) seepage control; 2) slope instability; and 3) vegetation overgrowth. Seepage can be controlled through proper engineering with a seepage cutoff system and a filter drainage system. Slope stability can be improved by constructing flatter slopes, earth/rock fill stabilization berms or drainage systems that will minimize pore pressure development. Vegetation growth problems can be amended through vegetation removal, maintenance and the establishment of a low maintenance ground cover. Earth embankment problems also fall into three categories: 1) spillway capacities; 2) structural stability; and 3) drawdown facilities. Spillway capacity deficiencies can be corrected through improved discharge efficiencies: 1) increasing spillway crest lengths; 2) adding auxiliary spillway sections; and 3) raising the top of dam elevations. Structural stability can be improved by buttressing the downstream face with mass concrete, and post-tensioned anchoring of the section the bedrock foundation. Drawdown facilities are commonly corrected by replacing gates and operating mechanisms. Case studies of improved dams also depict additional strategies for correcting dam deficiencies.

As a result of the heightened awareness and activity concerning dam safety, dam owners have implemented rehabilitation projects and developed programs for inspection and maintenance of the dams. Furthermore, several states have enacted regulations to support compliance with current dam safety criteria.

9

Calhoun, R., & Hutchison, S. (1981). Decision-making in old age: Cautiousness and rigidity. International Journal of Aging & Human Development, 13(2), 89-98.

Key Words: Public perceptions of risk, public behavior under risk.

The purpose of this study was to test the findings of Botwinick's work on cautiousness and decision-making in old age, with an examination of two factors not previously studied: rigidity and certainty of decision outcome.

This study was conducted by giving a group of 45 females and 19 males, who had a mean age of 69 years, the Choice Dilemmas Questionnaire (CDQ), which measures varying

degrees of vicarious risk-taking. The participants were broken down into two groups: the first group was forced to give responses, while the second group could elect no choice if they wished to. The responses to the questionnaire that the participants could select from probability alternatives which ranged from 10% to 100%.

The results were that when given the opportunity not to respond or make a decision, the elderly person would generally choose such an option. It was also found that their decisions would be considerably more conservative when rendered regarding a younger persons life.

10

Campbell, D. C. (1981). Application of risk and uncertainty analysis in the principles, standards and procedures of the U. S. Water Resources Council. In Y. Y. Haimes (Ed.), Risk/benefit analysis in water resources planning and management (pp. 157-162). New York: Plenum Press.

Key Words: Water supply planning, Monte Carlo simulation technique for measurement of risk and uncertainty, all planning steps.

This article discusses the Water Resource Council's (WRC) 1979 proposal for establishing the principles, standards and procedures to respond to President Carter's directive to consider "uncertainty and risk of costs and benefits" related to federal water resource planning. In the preliminary draft from WRC, use of the "Monte Carlo" simulation technique was recommended as the principal technique for measurement of risk and uncertainty. The author presents advantages and disadvantages to the Monte Carlo procedure. As of March 1980, the WRC allowed a variety of measurement techniques rather than only the Monte Carlo approach for measuring risk and uncertainty, but federal agencies have not adopted improved measurement techniques.

Strong points of the Monte Carlo procedure are: 1) the procedure is simplified and easily understood by persons involved in the project; 2) project managers and engineers tend to be comfortable in providing estimates for the procedure; and 3) use of the triangular distribution and subjective estimates allows planners to attain probabilistic information in situations where historical data is lacking, as is common with water resource projects.

Principal disadvantages of the Monte Carlo procedure include: 1) agency directors, project managers and, legislators may be reluctant to accept probabilistic information as it may detract from the strength of the analysis; 2) the project manager may provide biased estimates; and 3) the triangular distribution procedure fails to correlate components to one another.

Federal agencies have not adopted improved techniques because: 1) field planners lack incentives to analyze variables which are uncertain or risky; 2) little awareness is expressed of the inherent uncertainty in estimates of variables; 3) decision makers at the national level cannot agree on preferred techniques; and 4) field level workers lack adequate expertise in estimating risk and uncertainty. These problems may be corrected by increased awareness of the usefulness

of risk and uncertainty analysis, and providing practical techniques for measuring risk and uncertainty.

Rather than prescribe a specific procedure for handling risk and uncertainty, the WRC has opted for current risk simulation techniques for risk measurement. Although basic principles of risk and uncertainty were provided, useable procedures for quantification were inadequate. As a result, training programs are being developed for the personnel of affected agencies.

11

Cannell, W., & Otway, H. (1988). Audience perspectives in the communication of risks. Futures, 20, 519-531.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, all planning areas, all planning steps, risk communication.

Conflict resolution may be thwarted despite management efforts at risk communication because of public perception of how the risk is being managed. Three principal factors limit the effectiveness of risk communication are: 1) management desire to persuade rather than inform the public; 2) difficulty in controlling the communication of risk; and 3) the assumption that the public is either uninterested or unable to understand technical information and uncertainties. These factors are discussed in this article.

There are two distinct objectives of risk communication: 1) to ascertain that the public is adequately informed of a risk; and 2) to resolve conflicts related to technology. Three factors that could hamper conflict resolution despite efforts at risk communication are: 1) people interpret communication in a variety of ways; 2) people apply varying amounts of value on the information received; and 3) factors other than those directly associated with the risk, may influence individuals' views regarding risk.

Risk communication, as a means of informing people of pertinent facts, may become clouded by the desire to persuade the audience to adopt officially endorsed perceptions of risk. Risk communication cannot be expected to resolve the conflicts which inevitably arise in society over the choice and implementation of technologies. Attitudes may change eventually, but this change is unpredictable and occurs over an extended period of time because people evaluate new information in relation to their existing values and beliefs. The practical challenge of risk communications is to promote public understanding and appropriate responses to actual and potential hazards.

Three factors contribute to the difficulty of controlling the communication risks. First, there may be several independent points of risk communication. For example, after the accident at Three Mile Island, communication with the public occurred several different times. Second, organizations may wish to control information by not communicating, but silence may convey a different message to the public. People may believe the organization is hiding something, even if that is not the case. Finally, risk communication is never fully under the control of the entity

implementing it. The mass media is almost always involved. Careful attention should be given to the distinction between communicating risks and advising people about what actions to take to minimize these risks.

Decision makers often make certain assumptions which influence their communications of risk. Often decision makers will omit certain information, or not communicate the extent of uncertainties, believing that the public is either uninterested or unable to understand it. By making these assumptions, experts are implying judgements about the proper relationship in society between experts and lay persons - about where the line should be drawn between technical and political decisions. Communication is likely to be inhibited by omitting information that many lay people feel they have a right to know. Right-to-know legislation requires professionals to accept a broader position in risk communication. They are responsible for communicating balanced information regarding risks. The authors suggest that the development of a "professional code" requiring decision makers to consider the needs of all appropriate parties rather than focusing on the needs of one particular client. The most effective risk communications aims to inform all persons with a broad range of balanced information.

12

Cecilio, C. B. (1989). Private sector risk analysis: Applied to dam safety. Journal of Management in Engineering, 5, 379-384.

Key Words: Dam safety, public perceptions of risk, public behavior under risk, decision makers' attitudes toward risk, all planning steps.

The author proposes the use of risk cost analysis for selecting the design flood for new and existing dams. The difficulties involved in estimating risk costs for alternative designs are acknowledged and can be confronted through additional research of related technical procedures.

The incorporation of risk analysis in dam safety has progressed since the 1970's when it was first proposed by the American Society of Civil Engineers (ASCE). The author presents two factors which have slowed the utilization of risk analysis including the avoidance of estimating frequency of rare flood events and a reluctance to place a dollar value on human life. A common risk-based method utilized today involves hypothetical dam-break analysis and flood routings. A computer program simulating a dam failure aids in the selection of the spillway size so as to minimize damage from a failure. A more comprehensive risk analysis may include estimates of damage costs, loss of services from the dam, and construction costs of various design options. The final alternative would be the project with the most desirable risk-cost combination after considering probability of dam failure. This method does not place a value on human life, but may include an evacuation plan intended to reduce the potential loss of lives.

The author also cites limitations to risk analysis in dam safety. These include: 1) estimates regarding exceedance probabilities are not exact and costs related to various options may be sensitive to the estimates; 2) factors such as loss of life are difficult to include in

economic terms, but are very important in the decision making process; 3) future development below a dam may impact the risk analysis, but is generally unpredictable.

13

Chee, R. (1976). The Current State of Emergency Planning for Water Supply in the San Diego Area. (Emergency Water Allocation Project, Working Paper No. 3). Irvine: University of California.

Key Words: Emergency water supply planning, all planning steps.

This document describes the emergency water-planning capabilities of organizations involved in the administration and operation of municipal and industrial water supplies for the City of San Diego, California.

The San Diego County Water Authority (SDCWA) is a wholesale distributor providing water to 22 local water districts; it owns no storage facilities, and water is conveyed solely by gravity flow, eliminating the need to maintain pumping facilities. SDCWA does not have an emergency water plan other than lifting rebates for agricultural customers in times of water shortage. The 22 local water districts were contacted for water system and emergency planning information. Of these, only two had emergency disaster plans; four others had emergency water quality notification plans; seven could not provide information; and nine did not respond at all.

At the county level, the Unified San Diego County Emergency Services Organization (USDCESO) has compiled emergency plans for the county, and for each city within the county, that provide a central format to be modified to suit individual locations. The plans include a planning basis, USDCESO objectives, a general emergency plan, organization guidance, and task assignments. A list of supporting departments and agencies is also included. There are no specific plans for water emergencies. USDCESO assumes that water utilities would make most decisions during an emergency although, as already indicated, most utilities have no written emergency planning documents, thus inviting management-by-crisis committees in the event of a water disaster.

Finally, the California State Office of Emergency Services (OES) has developed a Utilities Emergency Plan that organizes emergency management teams and maintains the machinery to put them into action. The plan is activated when a state of emergency is declared by the governor. The OES does not appear to be doing any in-depth disaster planning or training for water shortages on a statewide basis.

The author provides a useful summary of emergency planning activities within the San Diego area. The reader should remember that this document addresses 1976 conditions which may have been revised in the decade that has followed.

14

Clarke, L. (1988). Explaining choices among technological risks. Social Problems, 35(1), 22-35.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, all planning areas, all planning steps, decision making process.

Sociologists have studied the issue of risk, but none of them have really explored the process in which decisions are made regarding acceptable levels of risk. This process is examined in an effort to determine why some risks are more acceptable than others. Utilizing case examples from nuclear power, Ford Pinto cars, and toxic chemical contamination, a sociological perspective regarding acceptable risks is developed. This analysis is based on organizational theory, decision making processes and bounded rationality.

This article includes an overview of previous findings concerning risk perception such as, people's tendency to take "mental short-cuts" in assessing risks resulting in biased estimations, perceptions of risk vary according to some social positions (i.e., citizen or expert), and the general public is more tolerant of risks where exposure appears to be voluntary, rather than involuntary. While focusing on perceptions of individuals, decision makers and the public in general, these previous studies neglected to address the role of organizations in determining acceptable levels of risk.

There have been times when experts have acted much as the public would using subjective, qualitative, and biased information to evaluate risk. For example, there is substantial evidence that officials determined the necessity of nuclear power for national defense and then decided it would be a national priority. The early estimations of the risks related to nuclear power were based on these premises. Furthermore, public opinion was not a primary consideration in the decision regarding the implementation of nuclear power, except to the extent that public may reject nuclear power. The examples of the Ford Pinto and toxic chemicals demonstrate similar procedures by organizations and their representatives in handling risk. "Garbage can" theories of decision making are utilized in instances where a "politically correct" risk assessment after the fact can create the illusion that a credible, logical sequence of decisions occurred. In this manner, risk assessments can be used to legitimate decisions for other groups and organizations. Generally, these risk assessments are not performed utilizing a quantitative rational method.

Psychological studies of risk fail to make a connection between perceptions of risk and the decision processes which directly impact the "allocation of resources toward and away from hazards" (Clarke, 1988). This author argues that organizations, not the public are the crucial agents in determining acceptable levels of risk. The agendas of organizations and policy makers are driven by the social structure (specifically, a capitalistic economy) in which they exist. It is the organizations that set the definition of acceptable risk and the terms of a cost-benefit payoff. In this case, power may be the most important factor in determining acceptable risk.

15

Covello, V. T. (1983). The perception of technological risks: A literature review. Technological Forecasting and Social Change, 23, 285-297.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, and methods of estimating risk, all planning areas, all planning steps.

This article is a literature review of risk in respect to the social sciences, human behavior, public perception, and factors which impact that perception. It also discusses the ways that technical experts perceive risk.

Short-comings of the data and research of the literature reviewed are presented. Many of the studies of risk utilized surveys of small, highly specialized and unrepresentative groups. Several influential variables such as demographic information, the order and manner in which survey questions are posed, and whether or not the respondent actually understands the questions, typically are not adequately considered in the studies reviewed.

There are several common findings of risk-related studies. Generally, people will underestimate or deny risk and uncertainty as a result of their need to reduce anxiety. People tend to overestimate risk from rare but highly consequential events. They also tend to underestimate risk from more common events. This behavior may be linked to the influence of the media. In addition, most people are over confident about their own risk estimates. Such over confidence can produce serious judgmental errors, and lead people to believe that they are comparatively immune to common hazards. Several differences between the typical technical expert's approach to risk, and the typical nonexpert's approach to risk are also addressed. For example, experts often give equal weight to voluntary and nonvoluntary risk. They tend to identify, estimate and evaluate risk in quantitative terms, and assign the same weight to different ways of dying. This contrasts with nonexperts who weigh involuntary risks more heavily, use qualitative methods to assess risk, and believe that some ways of dying are worse than others.

Overall, this article provides useful information regarding people's perceptions regarding risk and offers a good summary indicating the typical areas of weakness in the studies regarding risk. Most articles reviewed were related to risks of nuclear power and public perception of these risks.

16

Covello, V. T., von Winterfeldt, D., & Slovic, P. (1986). Risk communication: A review of the literature. Risk Abstracts, 3(4), 171-182.

Key Words: Risk communication, problems in risk communication, all planning areas, all planning steps.

This literature review addresses the communication of information about health and environmental risks such as: saccharin, the pesticide EDB, dioxin, AIDS, toxic wastes, smoking, driving without seat belts, and nuclear power. Four categories define the principal types of risk communication: 1) information and education; 2) behavior change and proactive actions; 3) disaster warnings and emergency information; and 4) joint problem solving and conflict resolution. Problems characteristic of each type of risk communication are also presented.

Risk communication is defined as "the act of conveying information between interested parties [agencies, corporations, unions, public interest groups, the media, scientists, individuals etc.] about (a) levels of health or environmental risks; (b) the significance or meaning of health or environmental risks; and (c) decisions, actions, or policies aimed at managing or controlling health or environmental risks."

Common problems related to the four types of risk communication include:

1) **Information and Education** - a) risk information is complex, highly technical and uncertain; therefore risk estimates can vary widely; b) government agencies sometimes lack public trust and credibility; c) experts and laypeople often define risk differently; d) government officials commonly use technical language unfamiliar to laypeople; e) risk information can be frightening, creating an atmosphere of fear and suspicion; f) people's beliefs are difficult to change even in the face of contrasting evidence; and g) people have difficulty interpreting probabilistic information.

2) **Behavior change and protective action** - a) people believe 'it can't happen to me;' b) people often resist government efforts designed to change behavior, for political reasons; c) the target audience of a behavior change is often unmotivated and uninvolved; and d) people rationalize their resistance to change.

3) **Disaster warnings and emergency information** - a) time pressures compound an already difficult situation; b) coordination between organizations often breaks down; c) warning systems often produce false alarms; d) people deny the possibility of a disaster; e) opportunities to save their homes and property often outweigh people's motivation to evacuate; and f) people require confirmation of a warning through several communication channels.

4) **Joint problem solving and conflict resolution** - a) it is difficult to hold public meetings in a highly emotionally charged atmosphere; b) officials often do not

understand the nature of conflict or sources of disagreement; c) media can aggravate communication problems by highlighting personal fears or sensational aspects of a situation; and d) individuals or groups involved in the process are often unwilling to compromise.

The authors make several general conclusions from this review: 1) the roots of most risk communication problems are deeply embedded in social issues; 2) interactive and participatory approaches to risk communication appear to be most effective; 3) 'there is no such entity as "the public"; instead there any many publics;' 4) government officials and individual citizens hold different views of risk problems; and 5) while a large amount of research mentions risk communication, the amount of literature that specifically addresses risk communication is very small.

17

Davis, S., Ratick, S., & Ballew, M. (1989). Uncertainty analysis for urban flood damage reduction benefits: Attitudes and practices of Corps of Engineer Economists (IWR Paper 89-P-1). Fort Belvoir, Virginia: U.S. Army Corps of Engineers.

Key Words: Decision makers attitudes toward risk, flood control, structural and nonstructural.

This research project was designed to help the Corps of Engineers provide better estimates of project benefits. Specifically, it will enable the Corps to provide more useful methods for reducing uncertainty in projecting the benefits of flood damage reduction.

This report was based on a survey of 24 Corps of Engineers district and division economists and social scientists. The questionnaire consisted of seven parts: 1) respondents' experience with evaluating flood damage reduction projects; 2) the relative importance of the benefits; 3) the magnitude, cost, and fund allocation for economic analysis as compared to other project tasks; 4) the experiences and propensity of the economists to use various techniques for displaying uncertainty; 5) economists' attitude to several provocative policy questions.

The major finding of the questionnaire are as follows:

1) Eighty percent of the group conformed to the assumption that the greatest part of the benefits from flood damage reduction projects comes from existing inundation reduction benefits.

2) Sixty-three percent of the effort for estimating benefits goes into tasks related to computing existing inundation reduction benefits.

3) The economists in this group considered insufficient data to be the greatest source of uncertainty in benefit analysis, although faulty data, unreliable methods, and unanticipated changes in conditions were all found to be significant problems at various stages in the planning process.

4) A large portion of respondents indicated that they consistently used subjective expert opinion, performed sensitivity analysis for key variables, and used qualitative descriptions in reports to handle uncertainty.

This questionnaire has given the Corps direction in their research concerning uncertainty in benefit analysis. A continued effort will focus on the primary sources of uncertainty, on techniques for illustrating uncertainty, and on techniques for displaying uncertainty.

18

Dawdy, D. R., & Lettenmaier, D. P. (1987). Initiative for risk-based flood design. Journal of Hydraulic Engineering, 113, 1041-1051.

Key Words: Flood design, decision makers' attitudes toward risk, all planning steps.

This article identifies two principal problems with the use of the probable maximum flood (PMF), the current standards for spillway design. The authors challenge the conclusion of the Interagency Advisory Committee on Water Data (IACWD) which recommended continued use of the PMF for risk assessment. New research should be pursued to provide a credible risk-based methodology for spillway design.

The two principal problems associated with PMF are: 1) the misperception by hydrologists that PMF has an exceedance probability of zero and 2) the lack of standardization in the methods used to calculate PMF which cause variations of true failure risks from site to site. The authors argue that it must be accepted that the probability of exceeding the PMF is not zero because there have been several recorded incidents which exceeded PMF. In addition, current methods for calculation of the PMF lack standardization; therefore errors occur causing the "true risk" to vary from site to site. To correct these problems, the authors propose additional research of several approaches for estimating the probability of PMF-like floods. These approaches fall into four specific areas: 1) exceedance theory (nonparametric approach); 2) exceedance theory (parametric approach); 3) simulation methods; and 4) paleoflood analysis.

19

Dooley, J. E. (1981). Decision making in environmental crisis situations. In H. C. Kunreuther & E. V. Ley (Eds.), The risk analysis controversy: An institutional perspective. Proceedings of a summer study on decision processes and institutional aspects of risk (pp. 79-90). Springer-Verlag, Germany: International Institute for Applied Systems Analysis.

Key Words: Decision making within crisis; emergency planning following floods, earthquakes, hurricanes, burst dams, and toxic spills; decision makers' attitudes toward risk.

This article discusses effective decision making in response to a disaster event. The author focuses on environmental crises including floods, earthquakes, hurricanes, burst dams and toxic spills. Common characteristics which affect people's ability to make effective decisions after a disaster are addressed.

An environmental crisis possesses key characteristics including: 1) a significant population or valuable resource is at risk; 2) the consequences and magnitude of the hazard are uncertain; 3) response time to the crisis is short; 4) information is of uncertain completeness and reliability; 5) the threat is nonhuman; and 6) the decision making authority is *ad hoc*. For example, if a fire occurs an established fire-fighting service will respond to the crisis, whereas when uncommon or more devastating disasters occur, *ad hoc* organizations often form to manage the situation.

The phases of a crisis are presented in five active stages: 1) awareness of the crisis; 2) response to the crisis including establishment of authority and appropriate resources; 3) new normalization of activities; 4) development of prior preparedness plans with established appropriate human and material resources, and warning systems; and 5) revision of previous preparedness plans according to lessons learned in the crisis. Stages four and five are known as feedback stages. Awareness of all five stages promotes effective risk management before, during and after a crisis.

Decision making in a crisis situation may lead to negative reactive behaviors: information distortion; group pathologies; narrowing of the cognitive processes; rigidities in programming; and lack of decision readiness. Utilization of a decision making structure may reduce these problematic characteristics and the author offers the decision making methods of procedural rationality and the construction of a decision support system as appropriate tools.

The use of models or structured approaches to crisis decision making may increase awareness of a difference between the *actual* and *perceived* situation and provide a means to control negative behaviors. This article is useful to water resource planners as they prepare plans for emergency situations. Familiarity and understanding of possible behaviors and methods for influencing them would be useful tools to have available before a crisis occurs.

20

Douglas, M. and Wildavsky, A. (1982). Risk and Culture. Berkeley, CA: University of California Press.

Key Words: Social bias and cultural bias, social organization, public and individual perceptions of risk, decision makers' attitudes toward risk, analytical methods, all planning methods.

This book examines how risk perception is founded largely on social and cultural bias. The authors trace this bias from its origins in individual personality traits and cognition, to the broad social principles underlying differing perceptions of risk. As such, they demonstrate how differences in risk perception, and subsequently risk analysis, stem directly from different social and cultural characteristics.

Within societies, common values lead to common fears, since the different social principles which guide behavior also affect the judgement of what dangers should be most feared and what risks are worth taking. Different societies select different dangers which they consider worth attention, making the perception of risks a social process. As a result, risk perception does not necessarily run parallel with the notions of objectivity and rationality, and different societies might approach the same danger with contrasting notions of its severity. Therefore, understanding risk perception means more than simply looking at the empirical causality of physical threats, but looking also at the different characteristics of social life which elicit different responses to danger.

To gain more insight into risk perception in general, therefore, the authors conclude that planners must first examine the ways in which people choose their social institutions. They suggest that prior to focussing on the physical dangers themselves, planners first recognize the cultural environment and the selection principles of the society perceiving the risk. This they hope will aid future generations in acquiring greater discretionary power in risk perception and analysis. By providing them with the tools to better understand the social biases which underlie the selection of risks, we will be providing them with the resilience to account for numerous risks in their planning processes, and avoid excess bias.

21

Dziegielewski, B., & Crews, J. E. (1986). Minimizing the cost of coping with droughts: Springfield, Illinois. Journal of Water Resources Planning and Management, 112, 419-438.

Key Words: Drought, emergency water supply plan, all perspective areas, all planning steps, analytical methods.

The authors present a planning method, the DROPS model (drought optimization procedures) which compares long and short term options for mitigating deficits in water supply. This article also describes a case study of Springfield, Illinois where the method was tested.

The DROPS model aids managers in the development of plans for water deficits emphasizing cost minimization and short-term deficit management programs. A series of factors must be examined when using the DROPS model. First, possible supply deficits must be determined. This is usually accomplished by comparing local drought records. The "worst drought on record" is generally used as the possible worst case scenario. The second step involves the formulation of drought emergency measures. In order to be effective, these measures should be applicable, technically feasible, and acceptable (or potentially acceptable) to affected residents. Then the effectiveness of each measure is calculated. Third, minimum cost shortage plans are formulated. The drought emergency measures which were developed in the previous step are integrated to identify the best plans. Then minimum total expenditures of the emergency plan are calculated, but only to the extent that reduced demand levels will be attained. Fourth, an assessment of water supply/conservation plans is made. The need for expanding the existing water supply is formulated based on estimates regarding the possibility of additional shortages during a prescribed planning period. The final step includes the selection of an emergency program which can be implemented during a water shortage crisis.

The DROPS model was implemented for City Water Light and Power (CWLP) in Springfield, Illinois. The model identified economic costs related to managing a water shortage in this area. Springfield officials approved the resultant emergency plan and initiated preliminary actions (including obtaining a permit for the construction of a temporary dam) to prepare for possible implementation of the plan in the future in response to a water shortage.

The DROPS model enables water supply managers to determine the least-cost drought mitigation method, in both the long and the short term. The DROPS model also provides managers with an opportunity to systematically consider the trade-offs between the costs of handling water supply shortages and the cost of long-term water supply/conservation.

22

Farber, S. (1987). The value of coastal wetlands for protection of property against hurricane wind damage. Journal of Environmental Economics and Management, 14, 143-151.

Key Words: Coastal zone protection, natural ecosystem problems.

This article assesses the value of wetlands by calculating their effectiveness as buffer zones in diminishing the intensity of hurricanes. This is accomplished by generating an equation based upon historical records and data from four hurricanes that hit within a 250 mile long coastal zone in Louisiana. This article only addresses damage caused by wind, not the damage caused by the flooding incurred from a hurricane.

The methodology is used to estimate a hurricane property damage function in which wetlands traversed by storms are an explicit damage determining variable. Given historic hurricane probabilities, an expected marginal damage function is derived that predicts the incremental property damage from winds due to loss of the wetlands buffer zone. The

probability of a hurricane hitting landfall in the gulf with winds in excess of 74 miles per hour is calculated to be 0.726 per year. This figure, divided by the total gulf coastal range of 720 miles, gives an annual probability per mile of 0.001. The derived equation using ordinary least squares and an unbiased mean estimator is:

$$E(D/P) = 5.6875\exp[d_0(-0.1150+0.0017*W)]$$

Where:

E = annual expected damages per capita
D = property damages due to winds
P = property at risk
d_0 = distance inland (including wetlands)
w = linear distance of wetlands

From which follows:

$$MV(d_0,w) = -[(-0.1150+0.0017(d_0+w))E(D/P)]$$

Where:
MV = marginal value

When the marginal value is computed, using mean values for input, the value of a one mile depth of wetland along the 250 mile long coastal zone equals $63,676 per year based upon 1980 dollars, or $6.82 per acre. This method was developed to help determine the economic feasibility of barrier island stabilization programs. It should be noted that this study did not take into account the effect of wetlands in reducing damages caused by tidal surge and subsequent flooding, which account for up to 94.6 percent of the total damages from a hurricane.

23

Fiorino, D.J. (1989). Technical and Democratic Values in Risk Analysis. Risk Analysis, 9(3), 293-299.

Key Words: Technical and democratic values, public and individual perceptions of risk, decision makers' attitudes toward risk, analytical methods, all planning areas.

This article examines the increasingly antagonistic relationship between technical and lay assessments and analyses of risk. The author feels that with experts puzzled by the apparent misinformation and irrationality behind lay attitudes toward risks, and the public suspicious about the arrogance and specialization of technical and administrative elites, frustrations in risk problem-solving will only continue to escalate. These frustrations manifest themselves in two opposing models of risk analysis; the democratic and the technical. Each model, and its underlying social values, describes a different approach to defining, assessing, and making decisions about risks. In general, the technical model is elitist, and the democratic model is

participatory. In an effort to explore the compatibility of the two models the author raises three questions: (1) can risk analysis be both technically rational and democratic (2) is political legitimacy incompatible with scientific validity, and (3) can technical values be reconciled with democratic ones. Exploring these questions, the author draws three basic conclusions:

1) The two sets of values can be easily distinguished, thus making the distinction between two contrasting models for risk analysis more facile.

2) The democratic model is not irrational or misinformed but as valid as the technical model.

3) Despite the fact that it is easier to define and analyze the technical model of risk analysis, risk professionals should not ignore the fact that it must be reconciled with the democratic model in order to deal legitimately and effectively with environmental risk perception.

By investigating the distinctions between these two sets of values, the author suggests the preliminary steps toward reconciling their differences and allowing for a possible synthesis between the two. He adds that we should focus less on refining and improving the technical model, and more on expanding our understanding of the democratic model and the mechanisms for reconciling the two sets of values. Such an effort might one day enable us to deal more legitimately and effectively with environmental risk problems.

24

Fischhoff, B. (1983). "Acceptable risk": The case of nuclear power. Journal of Policy Analysis and Management, New York: John Wiley and Sons.

Key Words: Decision makers' attitudes toward risk, Nuclear Regulatory Commission's approach in the development of "safety goals."

The United States Nuclear Regulatory Commission (NRC), responsible for safety regulations in nuclear power plants, recently established six "safety goals" for nuclear power plants. This paper discusses the NRC's approach in developing these safety goals.

The six safety goals are summarized as follows: 1) "Individual members of the public should...bear no significant additional risk to life and health as a result of nuclear power plant accidents; 2) "Societal risks to life and health associated with the operation of nuclear power plants should not be more than the risk of generating electricity by viable competing technologies and should not be a significant addition to other societal risks."; 3) "risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities...should not exceed 0.1 percent of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed"; 4) "the risk of death from cancer for people close to the plant should not exceed 0.1 percent of their cancer rate from all other causes."; 5) An improvement to a plant should cost less than $1,000 for each person-rem of radiation that the improvements

avert; and 6) probability of a large-scale core-melt in a year of reactor operation may not exceed one in 10,000.

The NRC had three concerns which led to the adoption of these goals: 1) provide an explicit statement of its overall safety policy to the public, confirming NRC commitment to the public's well being and giving the public criteria for monitoring NRC decisions; 2) provide regulatory relief for industry by lessening pressure to add new safety devices or introduce new operating procedures once a plant was declared safe; 3) clarify the role of probabilistic risk analysis (PRA) in NRC work. PRA is a procedure that decomposes a complex technical system into its various components, then assess as the probability of overall system failure by analyzing the behavior of its parts.

Four approaches to goal development are presented:

1) Formal analysis - involves an assessment of possible consequences of each goal which aides in the selection process.

2) Professional judgement - pools input from a variety of experts.

3) Political process - invites public participation in the decision making process through public hearings and workshops.

4) Revealed preferences - examines current public acceptance of other technological risks. While the NRC's approach did not utilize formal analysis, it did include the other three methods. As a result, the NRC's approach combined diverse perspectives from technical experts and the public. This diversity improved acceptability of the goals, yet it also contributed to a reduced coherence between the various provisions. The author believes that the use of goals is appropriate in the use of nuclear regulation because properly designed goals can: 1) simplify the regulatory process; 2) focus political discussions; 3) clarify industry's obligations; and 4) improve allocation of safety dollars. There are, however, some shortcomings of the current NRC policy such as: 1) no formal enforcement protocol exists; 2) in its advisory role these safety goals may become just another regulatory burden; 3) the possibility that the PRA cannot deliver the absolute risk estimates needed to evaluate compliance; and 4) application of the safety goals is carried out by technical experts -- the chance for public participation in individual risk decisions is eliminated.

25

Fischhoff, B. (1988). Judgement and decision making. In R. J. Sternberg and E. E.Smith (Eds.), The Psychology of Human Thought (pp. 153-187). New York: Cambridge University Press.

Key Words: Decision makers' attitudes toward risk, public behavior under risk, public perceptions of risk, all planning areas, all planning steps.

This article examines psychology's contribution to the understanding of decision making under uncertainty. Three approaches to understanding these complex decision making processes are discussed. They include: 1) subjective expected utility; 2) clinical judgement; and 3) intuitive statistics. Finally, psychologists biases are addressed.

Initially, psychologists utilized optimal decision making models developed by philosophers and economists to examine how individuals determine their best course of action. These models were derived from rules that people were thought to follow: 1) people make *rational* decisions; and 2) they make decisions that are *optimal* in that they choose the option which they believe will enable them to *maximize* their benefits. A principal criticism of this approach is the inability to test the metatheory that people are rational.

Psychologists made *clinical judgements* concerning their patients by using: 1) their clinical skills to diagnose and treat psychological problems; or 2) their psychometric tests to identify the best candidates for different jobs. One study concerning the decision making process used by a university admissions committee is presented as an example. Applicants were reviewed according to their Graduate Record Examination (GRE) score, overall grade point average (GPA), and undergraduate institution (QI). The following formula was used to predict the average admissions committee rating:

$$0.0032\ GRE + 1.02\ GPA + 0.0791\ QI$$

Study results indicated that committee members believed they were considering more variables, and that their consideration of the scores involved more than simple weighing and adding. Critical problems identified with this approach include: 1) people have difficulty evaluating their own complex cognitive process, therefore they often confuse what they did with what they intended to do; and 2) people have difficulty consistently implementing a complex decision making strategy since enormous amounts of information can overwhelm their computational capacity.

Findings from studies concerning people's ability to intuitively process statistical information, have developed two contradictory trends: 1) people do quite well; and 2) people do quite poorly. The difference stems from whether the tasks require counting or inference. People are good at assessing common measures of central tendency for what they just observed. However, performance deteriorates when the individual becomes overloaded with information. In making inferences, people rely upon heuristics or "general rules of thumb" to guide their judgements. These heuristics can lead to biases of judgement.

The following points indicate the influence that judgement biases may have upon individuals and their decision making processes:

1) The presence of judgmental bias in a decision making process is trivial since experience should have already taught people to avoid behavior that is bad for them;

2) A person may make a decision believed to be suboptimal, but it is possible that the individual subscribes to alternative theories of optimality.

3) A judgmental bias may be present, but it does not hinder a person's capability to succeed.

26

Fischhoff, B. (1985). Managing risk perceptions. Issues in Science and Technology, 2(1), 83-96.

Key Words: Public perceptions of risk, decision makers' attitudes toward risk, all planning areas, all planning steps.

The purpose of this article is to discuss seven characteristics of public perceptions of risk, and seven misconceptions risk managers often have when working with the public about risk controversies. Recently, the public has insisted on playing an active role in the management of new hazardous technologies. Nuclear power serves as an example for discussion in this paper.

Public perceptions of risk are characterized by seven tendencies: 1) people tend to simplify information when making decisions. They rely upon habit, tradition, the advice of friends, and general "rules of thumb"; 2) people do not readily change their minds after they have formed an opinion, in spite of contrasting evidence; 3) people remember what they see and their first impression has the greatest influence over their final opinion; 4) people cannot detect omissions in the information they receive, resulting in incorrect estimations of hazardous events; 5) people disagree more over the definition of risk than the amount of risk. Risk may be defined in probabilities of fatality, or 'reduced life expectancy.' These differing measures facilitate disagreement over the amount of "acceptable risk."; 6) people experience difficulty detecting inconsistencies in risk disputes including definitions of key words and the credibility of expert testimony; and 7) people have difficulty assessing expertise. Experts are often challenged to go beyond their scope of data to perform "educated guesses."

Risk managers often have misconceptions about how the public will handle risk controversies. Risk managers typically use a "quick fix" that will give the public what it wants while permitting industry or government officials to deal with risk issues free from conflict. The seven primary misconceptions are: 1) give the public the facts (public can be overwhelmed with a deluge of technical details); 2) sell the public the facts (denies intelligence of the public and the potential legitimacy of its perspectives); 3) keep risk policies consistent with previous policies (assumes public is happy with the way risks have been managed, which is often not

true); 4) give public clear-cut, non controversial statements of regulatory policy (assumes public is too unsophisticated to understand risk-benefit trade-offs); 5) abandon regulations and let the market place decide what are acceptable risks (there are too many risks for the public to fend for themselves, and the public has many risk misconceptions); 6) let the risk manager be the primary communicator with the public (poor public reception if the "expert" is a poor communicator); and 7) let local communities resolve their own risk-management problems (assumes communities will be flexible and realistic in assessing risk-benefit trade-offs).

Four steps of for successful risk management include: 1) describe the different decisions facing the various parties to the dispute; 2) identify the public's information needs and use the best available techniques for addressing them; 3) create a comprehensive protocol for organizing and reporting the manager's own decision making process; and 4) listen to what the public is trying to say. Making these efforts will put risk managers in the best possible position to build on the strengths of people's judgmental processes and avoid their weaknesses.

27

Fischhoff, B. (1987). Treating the public with risk communications: A public health perspective. Science, Technology and Human Values, 12, 3-19.

Key Words: Risk communication, all planning areas, all planning steps.

This article discusses the use of risk communication as a method of risk management in the public health field. Ideally, risk communication informs people of the courses of action that will provide them with the greatest protection at the least cost. Conveying risk related information can either help reduce risks or actually incur more risks. Public health risk communicators attempt to make risk assessment results available and understandable to the public. To negate the possibility of harmful risk communication, risk communicators need to develop standard procedures for the conveyance and evaluation of risk information.

Ineffective risk communication can actually make a situation worse than if no communication had occurred. For example, people may worry too much or too little about the wrong things. Worrying too much may cause a decrease in quality of life, and worrying too little may result in lost opportunities to defend oneself against risks.

At a minimum, effective risk communication involves the conveyance of information bearing a positive expected value. The communicated information should be 'generally regarded as safe' and 'likely to be somewhat effective.' To determine the expected value of a specific communication, risk communicators refer to empirical evidence from a basic science of risk communication, or evidence from a test of the communication itself.

Risk communicators need to create norms and standards for their profession, as have many scientist and engineers. These could include: completion of recognized training programs, submission of research to peer review prior to its acceptance, and archival preservation of data.

By doing this, risk communicators may establish their credibility and reduce the potential for negative risk communication.

28

Fischhoff, B., & Furby, L., & Gregory, R. (1987). Evaluating voluntary risks of injury. Accident Analysis and Prevention, 19(1) 51-62.

Key Words: Public's exhibited behavior under risk, cost assessment methods of risk, all planning areas, all planning steps, analytical methods.

This article discusses the importance for individuals and public officials to develop an understanding of the risks of both internal and external injuries. Advantages and disadvantages of two alternative methods for the assessment of costs of injuries are discussed: 1) expressed-preferences method; and 2) revealed-preferences method.

Internal injuries are voluntary and occur between individuals and people control the risks and benefits they incur. External injuries are caused by societal institutions and are both uncompensated and involuntary. Cost assessments of internal and external injuries are necessary so that individuals may gain awareness of the costs of injuries. As their awareness increases, individuals will be better equipped to determine how much they want to pay toward the reduction of risks. Likewise, public officials need to be informed of the costs for external injuries which are not contained among individuals. Costs of injury may appear as direct medical costs, decreased productivity, or indirect costs such as personal suffering, anxiety, or reduced quality of living.

The first method for assessing the costs of risk, involves asking people what they would be willing to pay for reduced risks - - their expressed preferences. The second method entails observing and evaluating people's behavior regarding risks - - their revealed preferences. These methods utilize several assumptions which may lead to error.

By asking people what cost they would be willing to pay to reduce a certain risk, it is assumed that people are optimal decision makers operating in a free market. However, several factors interfere with people's ability to optimize. For example, the quality and amount of information available to people affects their ability to optimize. A person's optimizing behavior is also limited by the choices presented to them. The range of options may be limited by, monopoly pressures, inaccurate beliefs concerning consumer preferences (i.e., "safety doesn't sell") which may inhibit the creation of desired options, societal constraints inflicted by advertisers, political activists etc., as they attempt to inform people of their current options and what their options really should be. The need to make decisions under pressure can limit the extent to which people's actions may mirror their preferences. In addition, errors may occur when asking an individual how they would respond in a particular situation: 1) the question is hypothetical; 2) the individual may be provided with information which may be lacking in an actual situation; and 3) the options available to the person answering a hypothetical question, may not be available in reality.

These opportunities for error may be controlled through improved communication and information programs, improved market activities providing additional options, and laws requiring the implementation of cost-effective safety measures.

29

Fischhoff, B., Slovic, P. & Lichtenstein, S. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 9 127-152.

Key Words: Public perceptions of risk, decision makers' attitudes toward risk, difference in public attitudes regarding risk of natural and man-made hazards, all planning areas, all planning steps.

This study examines measurement by expressed-preferences in which public attitudes are measured regarding the benefits and risks of various activities and technologies. The objective of this study is to evaluate the usefulness of questionnaires for investigating issues pertaining to risk-benefit trade-offs. Psychometric procedures were used to elicit quantitative judgements about perceived risk and benefits from various activities and technologies as well as judgements about levels of acceptable risk.

The participants in the study consisted of 76 members (and their spouses) of the League of Women Voters of Eugene, Oregon. In total, 52 women and 24 men were questioned regarding 30 different technologies and activities. For each of the 30 categories, there were questions concerning: 1) its perceived benefit to society; 2) its perceived risk; 3) the acceptability of its current level of risk; and 4) its position on each of nine dimensions of risk. The participants were divided into two groups, one answered questions concerning items 1, 3 and 4, while the other responded to questions regarding items 2, 3 and 4.

The respondents who participated in the study indicated that risk levels for many current activities and technologies are unacceptably high. Specifically, respondents (considering both groups) believed activity should be made less risky for all but seven of the 30 activities (Fischhoff, Slovic, & Lichtenstein, 1978, p. 135). A consistent, though not conclusive relationship between acceptable level of risk and perceived benefit, was found. The respondents believed that society should accept greater risk for activities that are more beneficial. The respondents also indicated that they would tolerate higher risks with voluntary activities than involuntary activities. For any given level of benefit, greater risk was tolerated if that risk was voluntary, immediate, known precisely, controllable and familiar. Activities with the most dread and certainly fatal consequences were deemed most in need of risk reduction. The study demonstrated little relationship between perceived risks and existing risks. Still, perceived risk declined slightly with overall benefit. Participants indicated that society currently tolerates several activities which were rated with very low benefits and very high risks, such as alcoholic beverages, handguns, motorcycles, and smoking. Participants indicated that society also tolerates several activities perceived to have high benefits and relatively low risk such as, prescription antibiotics, railroads, and vaccinations.

In order to answer the question, "How safe is safe enough?" studies involving multi-disciplinary and multi-method approaches are necessary. The expressed-preference type of study is not an independently adequate guide in determining actions by decision makers. People's present opinions do not necessarily indicate their behavior under risk and society's opinions should not really be the final judge for decisions concerning risk. Chauncy Starr's economic factors approach and others should be integrated with the expressed-preference method to determine acceptable risk-benefit characteristics of activities and technologies. It is also possible that the manner (or order) in which information is presented to the public may influence their perceptions regarding risk-benefit trade-offs.

30

Ford, D.T. (1984). Dredged-material disposal management model. Journal of Water Resources Planning and Management, 110 (1), 57-74.

Key Words: Dredging and dredge disposal, system operation management strategies, analytical methods, all planning steps.

This article illustrates efficient dredged-material disposal management strategies for the Delaware navigation system near Philadelphia. System operation is formulated and solved as a generalized, minimum cost, network flow programming problem. Application of the model defines cost-efficient, dynamic schemes for allocation of material to available disposal sites.

The Delaware river system is maintained in navigable condition by dredging 11,500,000 cubic yards of material annually. The dredged-material is disposed in 21 containment sites that are expected to be filled or unavailable due to lease expiration by 1999, if current dredge rates and management practices continue.

A number of capacity expansion alternatives were identified by a 1979 study. Capacity expansion alternatives include: 1) acquisition of new upland sites; 2) open-water disposal of dredge material; and 3) extension of leases on sites. Operation alternatives included: 1) dewatering of disposal sites; 2) increasing containment dike height; 3) reuse of dredged-material; 4) reduction of maintenance dredging; 5) use of deposition basins to reduce shoaling; 6) reduction of sediment erosion; and 7) improvements in site management.

The dredged-material disposal management model was developed so capacity expansion alternatives can be analyzed, the minimum-cost combination and schedule can be determined for new site acquisition and lease extension, and the minimum-net-cost operation policy for any specified system can be determined. The operation problem is formulated as a network-flow programming problem where decisions are visualized as flows in the arcs connecting the nodes of a network. The objective is to choose the flow in each arc to optimize the efficiency measure (which is cost for this problem). The disposal operation problem represents material sources and available disposal sites as nodes of the network, and transportation links and carry-over storages as arcs. The dewatering, consolidation, and densification of dredged-material is modeled with an arc gain factor.

A generalized computer program was developed, using structured analysis and structured programming, to implement the proposed disposal-system management model and evaluate alternative system capacity expansion plans.

A portion of the Delaware river system was analyzed using the dredged-material disposal management strategies for a time span of 50 years. The resulting network consisted of 877 nodes and 3,709 arcs. The minimum present-value net cost for system operation, with an annual discount rate of 7 5/8 percent, was determined to be $\$273 * 10^6$.

31

Ford, D.T. (1985). Dredged-material disposal system capacity expansion. Journal of Water Resources Planning and Management, 112(2), 277-291.

Key Words: Dredging and dredge disposal, optimal solution modeling, analytical methods.

The purpose of this article is to demonstrate three analytical tools that were used to identify capacity expansion alternatives for the Delaware river dredged-material disposal system. The disposal problem was solved using a Network-flow programming model of the disposal system operation, a geographic information system with associated attractiveness-mapping software, and a capacity expansion model.

Approximately 11,500,000 cubic yards of material are dredged annually from the Delaware river navigation system. At this rate, existing disposal sites were projected to be filled by 1990.

An earlier study, Ford (1984), detailed the Network-flow programming model which was used to determine the minimum cost and associated operation policy for the dredged-material disposal system. Potential new disposal sites within the Delaware river system were identified by: 1) selecting and collecting data for determining site suitability; 2) developing a computerized data base to manage the data; and 3) computing and mapping indices of site attractiveness, analyzing the maps in light of demands on the system, and soliciting public opinion on operation goals and constraints.

Data was managed using a grid-cell geographic information system (GIS). A regular, rectangular grid was superimposed on the study area and defining attributes of each cell were defined with this system. Using the defined attributes, relative attractiveness for each cell in the grid was represented in a map overlay; the most attractive cells were printed darkest, and the less attractive cells were left blank.

A capacity-expansion model was then developed to address site acquisition scheduling by searching a set of alternative acquisition plans, evaluating the total cost of each, and identifying the optimal plan by comparing the alternatives. The procedure selected for capacity expansion of the Delaware river system employs a branch-and-bound algorithm with embedded heuristic rules. The branch-and-bound procedure identifies the least-costly plan by dividing the universe

of alternative expansion plans into successively smaller, mutually-exclusive subsets (separating), choosing one of the subsets for further consideration (branching), estimating the minimum cost possible for the plans included in the subset (bounding), and comparing this cost with the cost of the best plan identified up to that point.

An example iteration of the branch-and-bound procedure is given. The authors note that these analytical tools are simplifications of the real-world system and, consequently, optimal solutions should be used as guidelines for decision making.

32

Fritz. C. E., & Marks, E. S. (1954). The NORC studies of human behavior in disaster. Journal of Social Issues, 10, 26-41.

Key Words: Public behavior under risk, public perceptions of risk, difference in public attitudes regarding natural and man-made risks, all planning areas, all planning steps.

This article presents the results of a study of people's behavior in disasters such as airplane crashes on a community, house explosions and fires, coal mine explosion, earthquakes and tornados, train wrecks and building collapses. A low incidence of panic following these disasters was reported. Factors which tend to enhance individual anxiety after a disaster are also defined.

Nearly 1000 individuals who had recently experienced a disaster were interviewed. Over 70 different types of disasters were represented in the sample. However, a majority of the research focused on six specific disasters which occurred in 1951 or 1952. Eight field trips were made to these disasters. Most of the investigations were underway within a few hours to three days after the disaster. The length of time in the field varied from one to three weeks. The methods for obtaining samples differed according to the situation. In smaller investigations, a combination of nonprobability and random area sampling was used; whereas, for example, in the large-scale study of the Arkansas tornado (over 400 interviews), five separate communities having differing types and degrees of involvement were selected and respondents from these communities were chosen by probability methods. Although the studies covered a wide range of problems, primary emphasis was put upon the reactions occurring during the emergency and post-emergency period, when the greatest stress and disorganization occurs. It is important to note that the data collected is either self-reported or reported by an individual's spouse.

Disaster literature focuses heavily upon panic behavior of people. However, this study indicates that panic behavior is *unusual*, rather than a common response to a disaster. *Confusion* appears to be the most prevalent reaction immediately following a disaster, and is often caused by individuals reacting according to independent and frequently conflicting appraisals of the situation. As a result, people may seem to be panicking, when they are actually acting in fairly rational, but conflicting manners.

The amount of warning time provided influences the rate of injury and death from a disaster. Individuals with less than a minute warning sustained a greater risk of injury or death than those with either no warning or more extensive warnings. Factors such as separation of family members during the disaster, accompanied by anxiety concerning the safety of family members and the trauma of encountering badly injured and mangled bodies as well as large numbers of dead bodies, aggravated emotional disturbance during and following a disaster.

33

Grether, D., and Plott, Charles. (1979). Economic Theory of Choice and the Preference Reversal Phenomenon. American Economic Review, 69, 623-38.

Key Words: Preference reversal phenomenon, preference theory, public and individual perceptions of risk, public behavior under risk, all planning areas.

This article questions a developing body of data within psychology which appears inconsistent with the preference theory of economics. This psychological phenomenon, which suggests the complete absence of optimization principles in human choice, holds broad implications with regard to certain accepted economic theories. The authors, therefore, conduct a series of experiments designed to disclaim the implications of these psychological findings as they apply to economics. To do so, they examined the psychologists' conclusions with two primary questions in mind: 1) whether or not the phenomenon they describe actually exists in situations where economic theory applies, and 2) whether or not the phenomenon can be explained through the application of standard economic theory.

The study compared the results of several experiments designed to examine the propensity of test subjects to reverse preferences in gambling situations. A number of different scenarios were created to control for both the economic and psychological explanations of the preference reversal phenomenon. In one instance, subjects were exposed to three pairs of gambles and asked to state either their preference or indifference in each pair. Following this, the subjects were given a randomly ordered list of twelve bets and asked to give the reservation price they would assign to each (the smallest price for which they would sell a ticket to each particular bet). Finally, the subjects were asked to repeat the first process with three new pairs of gambles. It is important to note that the three pairs of gambles in step 1 as well as those in step 3 comprised the list of 12 bets provided in step 2. To be consistent with the preference theory and the principle of optimization, the patterns that subjects used when assigning a dollar value to particular gambles in step 2 should have been reflected in the preference/indifference disclosed in steps 1 and 3. The authors found, however, that such consistency was not the norm. Instead, preference reversal was encountered most often, uncovering the psychologists' suspected inconsistencies in the traditional statements of preference theory and the principle of optimization.

As the authors concede, these results were not expected at the outset of the study, and the preference reversal phenomenon implied by the psychologists' data did indeed play a role in the test subjects' choices. The notion that preference theory and its related theories of

optimization are subject to exception, therefore, was supported. The authors add, however, that despite the possibility of inconsistencies within these theories, discarding them would not be advisable, since currently no alternative economic theories appear to be capable of covering the same extremely broad range of phenomena.

34

Goldsmith, R. (1984). Personality characteristics associated with adaption-innovation. Journal of Psychology, 117, 159-165.

Key Words: Public perceptions of risk.

This article studies hypothesized relationships between the Kirton Adoption Innovation Inventory, which is a standardized test for cognitive style leading to characteristic patterns of problem solving and decision making, and scales measuring; dogmatism, sensation seeking, risk taking and innovation.

This study was conducted utilizing four psychological tests: Kirton Adoption Innovation Inventory, Jackson Personality Inventory, Arousal-seeking Tendency Instrument, and the Eysneck Personality Inventory. These four surveys were submitted to a group and then the results of the latter three were used to verify the Kirton Adoption Innovation Inventory test.

The study found that there was a fairly good correlation between the four tests, thus giving credibility to Kirton's theory and scale.

35

Haimes, Y. Y. (1981). Risk benefit analysis in a multiobjective framework. In Y. Y. Haimes (Ed.), Risk/benefit analysis in water resources planning and management (pp. 89-122). New York: Plenum Press.

Key Words: Decision makers' attitudes toward risk, risk-benefit analysis using a multiobjective framework, all planning areas, all planning steps, analytical methods.

This article presents a multiobjective framework for risk-benefit analysis. This multiobjective approach integrates quantitative scientific and technological information with qualitative subjective and judgmental preferences. The Surrogate Worth Trade-off (SWT) Method is discussed as a part of multiobjective risk-benefit analysis.

Current state-of-the-art models are inadequate for measuring risk related to water resource systems. Elements of uncertainty as well as the interplay between humans and technology pose modeling challenges. Risk probabilities must account for the "human element" which may introduce error into a process.

Ideally, models enable risk decision makers to properly value, evaluate and consider risks in the decision making process. In order for such models to be effective, the decision maker must be cognizant of the utility, attributes and limitations of the model employed for risk assessment. Decision and policy makers receive risk models and system analysis with skepticism for many reasons such as: 1) too much modeling is delegated to persons lacking adequate understanding of models; 2) over-emphasis in the option of using computers and under-emphasis of efficient use of human resources; 3) insufficient planning and resources for model maintenance and management; 4) lack of communication among modelers, users, and affected parties; 5) lack of interdisciplinary modeling; 6) insufficient data planning; and 7) lack of consideration of multiple objectives in models.

The Surrogate Worth Trade-off (SWT) method is a method for optimizing and analyzing multiple noncommensurable objective functions. Primary to multiobjective analysis is the Pareto optimal concept where improvement to one objective can be accomplished only by degrading another. The SWT method develops a set of Pareto optimal solutions as well as competing objectives with consistent trade-offs. The decision maker, supplied with this trade-off information, decides whether or not the trade-offs are desirable. The SWT method is important because it leaves the technical, quantitative-predictive aspects of evaluation to specialized analysts and clearly gives the decision maker(s) the right and responsibility to evaluate the merits of improving any one objective at the expense of any other.

The multiobjective approach will become more effective and useful as: 1) reluctance and skepticism regarding modeling decreases; 2) the concept of multiobjective optimization replaces more traditional, restricted and limited concept of simple objective optimization; and 3) more risk analysts realize that a proper framework which enhances dialogue among analysts, decision makers, and the affected individuals is necessary.

36

Haimes, Y. (1979) The Worth of Streamflow Data in Water Resources Planning: Computational Results. Water Resources Research, 15(6), 1335-1342.

Key Words: Decision makers' attitudes toward risk, water supply planning emphasizing drought, economics.

The purpose of this paper is to illustrate the method for evaluating the worth of streamflow data in reducing planning uncertainty in water resource management.

The methodology is to economically justify the period of stream flow data collection. This is accomplished by placing a value on the possible results of uncertainties, which were caused by a shortage of data. This value is then used as a basis for deciding upon the optimum period of data collection, based upon cost worth trade offs. Haimes proposes an economic method for graphically evaluating the data collection period, based upon six computed inputs:

1) calculation of period of data record versus the relative accuracy of the data (deviation is used as the measure of relative accuracy);
2) calculation of cost of data collection periods versus accuracy of the data record;
3) develop penalty matrixes (the set of all viable solutions for each data period record);
4) calculate the expected penalties in water supply due to each viable solution in the penalty matrix;
5) calculate the expected penalties in monetary losses due to each viable solution in the penalty matrix;
6) calculate the forgone benefits cost of waiting for the study period to be completed.

Then for each survey period select the optimal compromise between the expected water shortage and the expected monetary penalty. To these optimal compromises, tally each net expected cost. Net expected cost equals the cost of collecting data plus the cost of forgone benefits plus the expected penalties in monetary losses. Finally choose the optimal compromise solution based upon the expected water shortage and the net expected cost.

In this computational analysis it is shown that the expected objective values depend both on the length of the data record and on the planning model. These methods relate the worth of data to the planning uncertainties. This method also permits interaction with prospective planners to account for the various trade-offs inherent in the design and implementation of a data collection program.

37

Hall, W. A. (1981). Risk/benefit trade-off analysis in water resources planning. In Y. Y. Haimes (Ed.), Risk/benefit analysis in water resources planning and management (pp. 31-40). New York: Plenum Press.

Key Words: Water supply planning, risk measurement techniques for water resource planning, all planning steps, analytical methods.

This article addresses the relationship between the value of water resources and reliability of their availability. A known level of reliability is needed to predict the beneficial use of a resource, since a resource will not be used unless the user is reasonably sure that the actual reliability in the future will not fall below the necessary level for that use. The Monte Carlo simulation method, as well as other techniques which may be useful in the measurement of risks related to water resource planning, are discussed.

The Monte Carlo simulation considers reliability involving various combinations of streamflows in sequence. To produce the optimum trade-off between resource quantity and reliability levels two concerns must be addressed: 1) probabilities of sequences of streamflow quantities; and 2) quantification of supply including, duration, magnitude, and temporal distribution of a resource shortage. An analytical procedure such as the classical mass balance

could be used as an initial trial to reduce the numbers of iterations needed to optimize the system. Changes in operational procedures can shift the risk and should be noted.

The author does not necessarily advocate the status quo in utilizing the Monte Carlo simulation in measuring risk and assessing corresponding probability for independent and non-independent events, but rather advises caution in the development and evaluation of the validity of alternative procedures.

38

Harman, D. (1984). Lessons learned about emergency preparedness. Public Management, March, 5-8.

Key Words: Emergency planning, all perspective areas, all planning steps.

The purpose of this article is to demonstrate how the City of Alexandria, Virginia learned lessons from past flooding events and what the community has done to improve their posture through emergency preparedness training and disaster exercises.

Emergency plans should address the hazards which are most likely to occur in the area. They should also include "common sense needs" like a list of appropriate telephone numbers including the team of people called to respond to an emergency. A broad spectrum of talents and experience is useful in the response team. Everyone from a member of the city council to dispatchers for the public safety department, may be effective in the team. The media are also an important factor in an emergency since they play an essential role in communicating information to the public on the situation. On the other hand, the media can be a hindrance as reporters may be seeking an exciting picture or story. The development and maintenance of an effective intergovernmental agreement concerning emergency situations is crucial in optimizing coordinated responses for emergencies that cross governmental boundaries. In addition, computerized information systems and resource libraries are essential tools in achieving effective and efficient responses to emergencies.

It is also important to recognize the human dimension of an emergency, since this factor may cause alterations in the implementation of an emergency plan. Studies have demonstrated the need to 'decompress' people and time for a careful transition from a stressful situation or disaster scene. It is important for administrators to train and re-train in preparation for the implementation of the emergency plan. After responding to an emergency situation, a follow-up meeting to discuss potential improvements in a plan is essential for improved response in the future.

39

Hazen, R. (1975). Managua earthquake: Some lessons in design and management. Journal of the American Water Works Association, 67, 324-326.

Key Words: Emergency water planning, earthquakes, all planning areas.

The author recounts the effects of the 1972 earthquake on the Managua water supply system and details recommendations to increase the system's resistance to future disasters.

In 1972, the population of Managua, Nicaragua, numbered nearly 400,000. The water supply system was fed principally from Lake Asososca, an extinct volcano crater west of the city. Managua sits on a line of volcanos that extend nearly the full length of Nicaragua. Earth tremors are common, and devastating earthquakes occurred in 1931 and 1972. The 1972 earthquake measured 6.5 on the Richter scale.

The Lake Asososca pumping station is located on the steep slope of the crater. Although the access road was destroyed by slides of the crater walls, the pumping station, force main, anchor blocks, and immediately adjacent ground were undisturbed by the earthquake. The facilities had been designed to be earthquake resistant. Anchor bolts around the base of the surge tank adjacent to the pumping station sustained an elongation of five-eighths of an inch. The bolt elongation was nearly uniform around the circumference of the tank, indicating that the structure had been rocked back and forth by the tremor. After the earthquake, four wells, yielding 2 mgd, were drilled on the south side of the city to supplement supplies from Lake Asososca.

The transmission and distribution systems sustained major damage. Two months after the earthquake, 400 water-main failures had been located and repaired, yet inordinately high water pumpage indicated that many leaks remained undetected. In the center of the city, destruction was so extensive that no immediate attempts were made to restore service; laterals were simply valved off at both ends. The water-main failures were primarily caused by lateral and vertical movement of the earth, as much as 20 and 10 cm, respectively. Asbestos-cement pipe and old gray-iron cast pipe failures were mostly shear breaks across the barrel. In large diameter pipes of both ductile iron and gray iron, failures were caused by joint separation rather than pipe breakage. Other service failures usually occurred at the corporation-cock or meter-box connection. Saddles were used for service connections to asbestos-cement pipe but not for cast iron. Prior to the tremor, there were 38,000 connections, 100 percent metered. Overnight, connections dropped to 17,200. In spite of this, water pumpage two months after the earthquake equaled that of before the disaster.

Three 2.5 mgd reservoirs were in service at the time of the earthquake; a fourth was empty due to maintenance and repairs and sustained less damage than the others. Earthquake damage included (1) vertical and horizontal hairline cracks in the walls; (2) cracks from inside to outside of walls and from bottom to top of foundation walls; (3) settling of columns and foundation walls, as much as four inches, causing failure of water stops and seals; and (4) circumferential cracks at both top and bottom of the inside columns. Additionally, large flows

of water through the cracks and breaks eroded the soil beneath the slab and foundation walls. Grouting below the tanks should reduce washouts in future earthquakes, but structural failures can be expected.

Steps to minimize the impacts of future earthquakes on the city's water system include (1) developing a flexible lining for reservoirs and designing smaller-capacity tanks; (2) developing a second water supply from a less vulnerable source; (3) using nonbrittle pipe for water mains and services, with flexible connections; (4) maintaining a large stock of tools, excavating equipment, trucks, and repair supplies; (5) enlisting an auxiliary repair force to serve in emergencies, such as employees of contractors and plumbing concerns; (6) developing a program so that the less damaged parts of the system with an operable source can be quickly segregated and kept under pressure; and (7) maintaining standby engine-driven pumps on two or three wells to provide an immediate supply of potable water in an emergency.

The article offers useful information to planners seeking to increase the earthquake resistance of water supply systems.

40

Hobbs, B., Patterson, C., Maciejowski, M., & Haimes, Y. (1988). Risk Analysis of Aquifer Contamination by Brine. Journal of Water Resources Planning and Management, 114(6), 667-685.

Key Words: Natural ecosystem problems, decision makers' attitudes toward risk, groundwater, analytical methods.

This article assesses the underground disposal of liquid wastes and their possible contamination of groundwater. The prediction of their impacts is subject to many uncertainties. This paper develops and applies a risk analysis model that addresses several of these uncertainties. The model inputs are hydrogeologic parameters, the reliability of waste disposal, and demographic information. The outputs of the model are probability distributions of the number of rural home wells or municipal ground water well fields that may be contaminated. The model was used to analyze the risks posed by annular disposal of oil and gas brines in Ohio.

This article attempts to quantify the risk in annular disposal of oil and gas brines, on private and municipal wells in the Black Hand Sandstone and Buried Valley Aquifers in Ohio. The risk model is summarized by the following equation, which calculates the probability of N water supply wells being contaminated due to operation of a single annular disposal well:

$$P(N/\Theta) = \Sigma_D \Sigma_M P[N/A(D,M,\Theta)]P(D)P(M)$$

Where:

$P(X/Y)$ = conditional probability of event X given condition Y

N	=	number of water supply wells contaminated due to operation of a single annular disposal well
Θ	=	aquifer parameters (porosity, dispersivity, etc.)
D	=	duration of brine leak from the annular disposal well
M	=	magnitude of leak, in units of mass/time
$A(D,M)$	=	spatial area of brine contamination of groundwater
$P(D)$	=	probability distribution of leak durations
$P(M)$	=	probability distribution of leak magnitudes

The U.S.G.S. method of characteristics (MOC) model of two-dimensional solute transport in groundwater was used to generate the area of contamination ($A(,D,M)$) based upon the aquifer parameters (Θ).

The probable damages caused to groundwater by annular disposal of oil and gas brines in the Black Hand Sandstone and Buried Valley Aquifers in Ohio were calculated to be $207,800 for a twenty year period. The benefits of annular disposal were calculated to be $400,000 per year.

This article concludes that the economic benefits of continued disposal by this method outweigh the economic risks associated with the contamination. This conclusion was derived based upon the assumptions that no direct health problems arose and that the solute transport in the aquifer behaved in a linear system fashion.

41

Hochstein, A. B. (1975). Optimum dredged depth in inland waterway. Journal of the Waterways Harbors and Coastal Engineering Division, 101(WW4), 331-342.

Key Words: Dredging, optimal channel dimensions, all planning steps, analytical methods.

The purpose of this paper is to present a process for determining optimal solutions for channelization of a reach of open river with sufficiently large oscillation of water levels so that it may service a given demand for transportation. Dredging and training, the basic methods for improving navigation conditions in these waterways are discussed in this article. This paper did not attempt to consider optimization of multiple uses and regulation water resources topics.

The challenge lies in the determination of optimal channel dimensions where the sum of dredging cost and towing cost is the least:

$$C = D(d_c) + B(d_c)$$

where C = total cost, $D(d_c)$ = dredging cost for channel dimension d_c, and $B(d_c)$ = tow cost for channel dimension d_c.

Due to their complexity, dredging and flotilla cost functions (*D* and *B*) cannot be represented in simple form. As a result, an approximation algorithm outlined in the following steps, is proposed:

1) Define a stratification of possible variants of minimum guaranteed channel dimensions;

2) For each variant of minimum guaranteed channel dimensions, determine the volume of required dredging and related costs;

3) For each minimum guaranteed channel depth and for each type of tow (vessels) which require depth greater than the given minimum depth, calculate the average usable draft (throughout the year or monthly);

4) For each variant of minimum guaranteed channel dimensions determine the amount of cargo carried by tows (vessels), which have dimensions exceeding the minimum existing channel capacity, and calculate costs associated with transporting this cargo; and

5) Select the minimum guaranteed channel dimensions for which dredging costs plus transportation costs are least.

42

Hooker, D. (1981). A Regional Response to Water Supply Emergencies. Journal of the American Water Works Association, 73, 232-237.

Key Words: Emergency water supply planning, all planning steps.

The author describes the Washington Water Supply Emergency Agreement (WSEA), which is a coordinated areawide water conservation and water use plan. The paper reviews the components of the WSEA and the agencies involved.

The Washington Water Supply Emergency Agreement is described as a unique cooperative regional effort of major water supply agencies operating within 19 political jurisdictions in two states and the District of Columbia. The WSEA was created in response to drought conditions in 1977 and required two years to reach official agreement. The emergency plan covers water emergency conditions caused by extreme shortages, equipment failures, sabotage, or pollution. The plan not only coordinates areawide water conservation and curtailed water use during periods of critical water supply shortages but also facilitates tailored water consumption based on combined quantities available to the regional signatories.

The plan specifies actions to be taken by the water suppliers at the alert, restriction, and emergency stages as well as specifying exact media information for release at each stage. Alert and restriction stages call for voluntary customer measures; however, the emergency stage

mandates compliance and includes enforcement and penalties. Water shortage stages are defined by the Potomac River Low Flow Allocation Agreement, which identifies Potomac River fluctuations and allocates available water to suppliers according to a set formula.

This concise article provides a comprehensive description of a carefully developed regional contingency plan. The article does not discuss the evolution of planning which culminated in the agreement, nor the types of potential penalties that could be levied on noncompliant customers during emergency stages of a water shortage.

43

Jackson, W., Shelby, B., Martines, A., & Van Haveren, B. (1989). An Interdisciplinary Process for Protecting Instream Flows. Journal of Soil & Water Conservation, 44, 121-126.

Key Words: Natural ecosystem problems, navigation, instream flows, all planning steps, analytical methods.

This article proposes a process for determining instream flow needs to maintain ecosystems, habitat, and recreational opportunities. To protect these attributes quantification and justification of instream flow requirements is necessary. Formulation of legal, technical, and administrative strategies are imperative to preserve streamflows. To achieve this sort of flexibility, it is necessary to rely on integration of disciplines throughout the process, including study design, selection of methods, data gathering, evaluation of results, and formulation of protection recommendations.

This article emphasizes a team-based evaluation process rather than specific methods. This value-based approach allows for flexibility to mold an assessment to a specific situation. This process consists of six basic steps:

1) Preliminary assessment and study design
2) Description of flow-dependent values
3) Description and quantification of hydrology and geomorphology
4) Description of the effects of flows on resource values
5) Identification of minimum flows to protect values
6) Development of a strategy to protect flows

This process reflects a fully interactive participation by a group of specialists producing an interdisciplinary product. In this type of an evaluation process, there must be an interconnection of project components so that each supports the other and leads to a definable resource solution.

The value-based interdisciplinary approach to instream flow determinations has proved both efficient and economical. It has the flexibility to deal with a variety of issues, institutions, physical conditions, and processes. This is essential because every in-stream flow assessment represents different resource values, administrative issues, technical considerations, and legal environments. The variables are so intensely different in each case that standard technological

methods are at best only useful tools available to specialists and at worst may be misleading, inapplicable, or irrelevant and distract from effective problem analysis.

44

James, L. D., & Hall, B. (1986). Risk information for floodplain management. Journal of Water Resources Planning and Management, 112, 485-499.

Key Words: Flood damage control, public perceptions of risk, decision makers' attitudes toward risk, all planning steps.

This article presents alternatives to improve current measures used to control flood damage. These instruments focus on improving communication of average economic loss: 1) reliable estimates of average economic losses due to floods; 2) efficient delivery of information; and 3) effective interaction between public and private entities. In the 1930's structural measures were initiated in an effort to reduce flood damage. In the 1960's as flood damage continued to increase, nonstructural measures were pursued because the protective structures such as dams, levees, and channels, were found to fail. Despite these measures, damage from floods continues to grow. Efforts today combine structural and nonstructural measures. An important aspect of nonstructural measures is aimed at communicating risk and average economic loss to citizens who may be affected by a flood.

The current 100 year flood safety standard does not adequately distinguish between areas with minimal flood problems and areas with potentially significant hazards to property and life. As a result, an effective alternative to this standard includes: 1) increased regulatory equity and consistency in the way individuals and communities may be affected by a flood; and 2) providing floodplain occupants with additional information regarding potential economic loss and personal danger. Such information enhances individual control over the risk situation.

Flood mitigation involves a combination of structural measures implemented by government and nonstructural measures activated by floodplain occupants. Improved risk communication between experts and the general public improves the effectiveness of these protective measures.

45

James, M. K., & Stark, K. P. (1986). Risk analysis: Cyclones, and shipping accidents. Oceanus, 29, 107-108.

Key Words: Navigation, coastal zones, all risk perspectives, all planning steps, analytical methods.

This article demonstrates how "fault tree" computer simulations can be used for risk analysis to minimize coastal damage and shipping accidents caused by cyclones.

Strong natural and constructed structures along the shore weaken the waves as they strike the shore. Detailed computer simulations utilizing historical data aid in the construction of shoreline and off-shore structures. Computer simulations have also become increasingly important in performing risk analysis for navigation. Increased shipping traffic has resulted in several near-misses and the sinking of at least one trawler along the Queensland coast. Fault trees, used extensively to graphically evaluate safety, represent the decision gates or "faults" that lead to an accident outcome. The accident occurrence can than be traced back to causal events that explain how and why the accident occurred. The models use fault trees that draw upon historical data to represent accident scenarios. Fuzzy set theory is used to depict mariners' decision processes.

The use of computer simulations and fault trees can avoid unnecessary shipping accidents and coastal damage by illustrating the patterns and effects of coastal storms such as cyclones.

46

Jones-Lee, M. W., Hammerton, M., & Philips, P. R. (1985). The value of safety: Results of a national sample survey. The Economic Journal, 95, 49-72.

Key Words: Public perceptions of risk (particularly transport risk), all planning areas, all planning steps, analytical methods of risk assessment.

The questionnaire method of risk assessment is used to discover people's attitudes regarding individual safety. Other studies, using the "willingness to pay" model focus only on individual marginal rates of substitution between wealth and risk of death or injury. In contrast, this study is concerned with people's perceptions regarding different ways of dying and the severity of injuries.

The survey was conducted between June and July of 1982 with a two-stage stratified random sample from 93 constituencies in England, Scotland and Wales. Overall, there were 1,103 full and 47 partial interviews. The questionnaire consisted of 37 questions falling into three categories: 1) valuation questions; 2) perception/consistency questions; and 3) factual and other questions. All questions presented probabilities in the form 'x in 100,000' in an effort to minimize bias. A follow-up survey was conducted about one month after the main study to test for temporal stability of responses. A subsample of 210 respondents were asked to answer questions from the original questionnaire.

The valuation category asked the respondent to estimate marginal rates of substitution including, death versus injury, their value of safety. For example, how much extra would you be prepared to pay for some different types of safety features? The perception/consistency questions asked about people's perception of transport risks, their ability to process simple probability information, and coherence. These questions also served as an internal consistency and temporal stability of valuation responses. For example, imagine that you have two different risks of being killed: in one, your risk of death is 2 in 100,000; in the other your risk of death is 20 in 100,000. You cannot avoid either of these risks but you can choose to have one of them

reduced. Which would you prefer: the risk of 2 in 100,000 reduced to 1 in 100,000 or the risk of 20 in 100,000 reduced to 15 in 100,000? The section of factual and other questions requested information such as age, income, and vehicle ownership.

The reliability of the responses are discussed in detail. The responses to each of the questions were compared against responses to other questions in order to determine the credibility of the responses. The results appear to reliably indicate the magnitude of typical marginal rates of substitution. These findings logically correspond with common sense and theory. As a result, it is concluded that the respondents were not overly prone to randomness or "mendacity" in their answers.

The results of the valuation questions apparently indicate a need for an increase in the value of statistical life by approximately *L*30,000. Responses to the perception/consistency questions indicated that most people are equally averse to dying in a transport accident as to the prospect of dying at work. The findings also indicate that people make clear distinctions among different ways of dying (i.e., cancer, heart disease, and motor accidents). As a result, people are willing to pay large amounts of money to avoid long periods of physical and psychological pain related to cancer deaths.

47

Kahneman, Daniel, and Tversky, Amos. (1982). The Psychology of Preferences. Scientific American, 246, 160-173.

Key Words: Preference reversal, risk-averse, risk-seeking, individual perceptions of risk, public behavior under risk, all planning areas.

This study examines peoples' tendencies to depart from objectivity when making decisions involving risks. The authors specifically investigate the patterns people follow in such departures, and assign mathematical explanations to them. With many professionals accepting the hypothesis that people generally make risk-averse decisions, the authors hoped to clear up some of the puzzles of rational choice, and develop a better understanding of the decision making process.

The study design consisted of a number of experimental surveys in which respondents were presented with different choice dilemmas, always involving risks. In each situation, the test subjects were asked to choose between certain and probable outcomes, where either gains or losses were at stake. If a subject preferred a certain outcome to a gamble with an equal or greater monetary expectation, the choice was described as risk-averse. If, on the other hand, an outcome was rejected in favor of a gamble with an equal or lower monetary expectation, the choice was considered risk-seeking.

The authors found that in the majority of choices, preferences between gains were risk-averse, and preferences between losses were risk-seeking. For example, when presented with a choice between (A) a sure gain of $80, and (B) an 85 percent chance of winning $100 and a

15 percent chance of winning nothing, most people made the risk-averse choice, preferring the sure gain of $80. Conversely, when faced with a choice between (A) a sure loss of $80, and (B) an 85 percent chance of losing $100 and a 15 percent chance of losing nothing, a large majority preferred the gamble to the sure loss. This pattern was indicative of both real decision dilemmas and hypothetical situations.

As an overall effort to better understand how people make decisions involving risk, this article raised several interesting questions regarding the basic premise of rational choice theory, indicating that often times people make risk-seeking decisions. In these instances, rationality seemingly took a back seat to individual personality traits in influencing people's decisions. From a planning perspective, this article raised the question as to the appropriate basis for including human experience in decision making theory, a question every planner will one day encounter.

48

Kalevela, S. A., & Radwan, A. E. (1988). International issues of transporting hazardous materials. Transportation Quarterly, 42(1), 125-139.

Key Words: Emergency water planning, transportation of hazardous materials, international transportation risk statistics, all risk perspectives, all planning steps.

The purpose of this article is to convey the results of an international survey exploring seven factors in the transportation of hazardous materials: 1) common means of transporting goods; 2) types of dangerous goods in the transport system; 3) accident record-keeping systems and accident statistics; 4) laws and regulations in the transport industry; 5) national organizations responsible for transportation safety of hazardous materials; 6) accident/disaster response systems; and 7) training and information in the transportation industry. Thirty percent of the surveys were returned, comprising 25 countries: Argentina, Brazil, Chile, Hong Kong, Hungary, India, Indonesia, Jamaica, Kenya, Korea, (Republic of Korea), Kuwait, Malawi, Netherlands, New Zealand, Pakistan, Saudi Arabia, South Africa, Taiwan, Trinidad, Venezuela, and Zambia. The author also provides a review of historical data concerning transportation of hazardous materials.

Findings from the authors' survey indicate that highway transportation is the most common mode of transportation. The most common types of transported hazardous substances are: 1) flammable substances; 2) explosives; 3) compressed gases; 4) irritating, combustible materials; and 5) corrosive and poisonous chemicals. All countries have general record keeping systems in place, but do not have designated departments to handle accident statistics specifically. All of the countries surveyed agreed upon the inadequacy of control and enforcement of national and international regulations regarding safe packaging (i.e., marking, labeling, and placarding) for transportation. All countries surveyed have established some type of disaster response system (police, military, fire, and ambulance personnel). However these systems are often inadequately equipped and lack proper training to mitigate hazardous material disasters. Driver training commonly applies only to vehicle operation. Before transporting

hazardous materials, most drivers receive general verbal instructions for safe handling of the materials.

According to historical data, the greatest number (74 percent) of accidents occur in roadway transportation, 18 percent occur during transportation by water, and only 5 percent occur by rail. The largest amount of material is transported by water. Water transportation accounts for 49 percent of the total for all substances. Transportation of material by pipeline and air were not included in these totals.

It is important to note that statistics concerning transport accidents are subject to error. Many areas of the world record only a few transport accidents, rather than all of them as they occur. Implementation of certain options and proper handling can prevent substances from being hazardous during transportation. Still, the practicality of implementing these options, and the assurance of "proper handling," are uncertain.

Transport accidents pose an interesting challenge to risk managers because they typically have low estimates of probability, but the potential consequences are serious. Historical data indicates that road transport possesses the highest frequency of accidents. The author's findings proved to be consistent with historical data.

49

Kaprow, M. (1985). Manufacturing danger: Fear and pollution in industrial society. American Anthropologist, 87, 342-356.

Key Words: Public perceptions of risk, public's behavior under risk, pollutants/toxic chemicals, all planning areas, all planning steps.

This article is an essay on Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers by Mary Douglas and Aaron Wildavsky. The author of this article recognizes that Risk and Culture makes a significant contribution to sociological research because it is the first study to compare ideologies about pollution in industrial and tribal communities. The author also agrees that pollution has been with society for centuries, however she disagrees that environmentalists are exaggerating the current situation. According to the author, pollution is compounding at an unprecedented rate. As a result, she criticizes Douglas and Wildavsky for their political statements accusing the environmental movement for encouraging excessive regulation.

Douglas and Wildavsky address two questions: why does every society disregard certain dangers while exaggerating other dangers, and why has this (specifically, the environmental movement) arisen in the United States? In response to the first question, Douglas and Wildavsky assert that people's beliefs regarding pollution are more a product of the culture than real danger. In response to the second question, they argue that environmentalism is a sect. In order to exist, sects need to grow and have enemies/opposition. Douglas and Wildavsky state that since America has always a number of sects, the environmental movement is strongest here.

The author of this article finds the greatest flaws in this second argument. She notes that environmentalism is stronger in countries such as, West Germany, Sweden, Norway, Holland and Japan and these countries have fewer sects than the United States.

Douglas and Wildavsky argue that environmentalists exaggerate the situation of the earth's environment. According to the author, Douglas and Wildavsky find the environmentalists' position regarding 'hidden technological contamination' similar to 'witchcraft accusations in tribal society.' The author of this paper argues that "evidence about occupational and environmental health proves how very opposed the interests of industry and the general public have always been," Douglas and Wildavsky trivialize actual hazards and "end up by eliminating danger altogether." From Douglas' and Wildavsky's point of view, 'moderns [use] advanced technology and [ask] those famous primitive questions as if there were no such thing as natural death rates, and no normal incidence of disease' (Kaprow, 1985, p. 348). The author asserts that environmental dangers are indeed real and that the environmental movement is a symptom of potential, pervasive breakdown.

50

Kasper. R. G. (1980). Perceptions of risk and their effects on decision making. In R. C. Schwing, & W. A. Albers, Jr. (Eds.), Societal risk assessment: How safe is safe enough? (pp. 71-84). New York: Plenum Press.

Key Words: Public perceptions of risk, decision makers' attitudes toward risk, public behavior under risk, all planning steps.

This article addresses the difference between the public and the decision makers' perceptions of risk. This difference fortifies conflict between the public and the experts in risk management. One factor that contributes to this conflict is the experts' belief in certain assumptions or "myths" regarding public behavior under risk.

Risk measures can be divided into two categories: 1) those that observe or calculate the risk of a process or project; and 2) those that rely upon perceptions of others who are assessing the risk. The first group of measures use long-term experience, experimental evidence, or sophisticated analytical calculations in estimating risk. Experts commonly employ such methods in estimating risk. The second group of measures explains people's estimations of risk based upon their own perceptions. Risk estimates derived from these two categories seldom agree.

The first method of estimating risk is not entirely objective. Subjective choices and assumptions of people's behavior are often made by experts in processes of calculating risk. Although certain assumptions regarding people's behavior under risk appear to hold constant, the author presents several examples indicating otherwise. For example, one assumption is that the public would rather undergo a risk rather than be inconvenienced. To disprove this assumption, the author cites an example where travelers who believed DC-10's were unsafe, went to great lengths to avoid flying on the aircraft. Another common assumption is that people always tend to judge risks being greater than they are in fact. This assumption is not valid

either, as is shown in a study in which a sample underestimated annual deaths caused by motor vehicles. There are two main consequences of making these assumptions: 1) an increase in propaganda and indoctrination instead of real progress toward solutions to exiting or potential problems; and 2) public erosion of trust and respect for the "experts."

Resolution of conflicts between the public and experts remain challenging. While incorporation of *all* public concerns may lead to excessive conservatism resulting in added costs and inefficient use of resources, expert decision making that does not respect the values of the public may underestimate risk and deepen public dissent. Although a complete answer is lacking, a softening of attitudes on *both* sides as well as public involvement in the decision making process early in project development may provide more positive results.

This article may be useful to the water resource planner by providing insight into people's perceptions of risk and their behavior in situations involving risk. This article also helps water resource planners to recognize some of their own perceptions and behaviors. With such information, planners may gain increased awareness concerning the difference between their views and the views of the public and how to minimize the resulting conflict.

51

Kasperson, R. E., & Pijawka, K. D. (1985). Societal response to hazards and major hazard events: Comparing natural and technological hazards. Public Administration Review, 45, 7-18.

Key Words: Public behavior under risk, public behavior after a disaster, all planning areas, all planning steps, risk management, hazard intervention.

This article addresses alternative management needs between natural hazards and technological hazards. Most of the examples of technological hazards in this article, focus on long term exposure to chemicals and nuclear power. The authors assert that natural hazards are relatively familiar and, therefore, the chain of events associated with them are familiar. As a result, managers generally know what precautionary steps to take before the event, as well as what should be done afterwards. In contrast, technical hazards are relatively unknown and little precedence exists on which to base judgments particularly when the consequences are chronic and the sources of exposure multiple. Management intervention usually occurs late in the chain of events with natural hazards since there is limited potential for preventing events. However, technical hazards possess more points for intervention and control.

Considering technological risks, intervention may occur at seven major points: 1) change people's demands for the technology; 2) substitute another technology; 3) halt initiating action; 4) prevent toxic releases etc.; 5) control exposure; 6) block consequences; and 7) mitigate consequences. There are three basic options concerning the control of technology: 1) laws may be implemented; 2) methods of persuasion may be utilized; and 3) those bearing the risk may be informed so they may choose to bear the risk or not. Cost-effectiveness analysis can be useful in determining which intervention or control to implement.

Other differences between natural and technological hazards include, public response to warnings to evacuate etc., person's psychological impact from the event, and people's reactions after a disaster. People react differently after a technical disaster for several reasons, the technical hazard was caused (or created) by humans, loss may not be physically observable, and the consequences remain uncertain. A political conflict is also likely to arise after a technical failure since people rely on the government to protect them from such risks.

Risk managers need to be aware that people respond differently to natural hazards than technical ones. Procedures found to be effective in dealing with natural hazards may not be appropriate after a technical accident. Technical hazards pose several new challenges to risk managers but also offer several alternative opportunities for control and/or intervention. A risk manager who understands and utilizes these options will be able to improve risk management.

52

Kasperson, R., Renn, O., Slovic, P., Brown, H., Emel, J., Goble, R., Kasperson, J.X., and Ratick, S. (1988). The Social Amplification of Risk: A Conceptual Framework. Risk Analysis, 8(2), 177-187.

Key words: Public perceptions of risk, public behavior under risk, analytical methods, natural ecosystem problems.

This article sets forth a conceptual framework that seeks to link systematically the technical assessment of risk with psychological, sociological, and cultural perspectives of risk perception and risk-related behavior. The main thesis is that hazards interact with psychological, social, institutional, and cultural processes in ways which may either amplify or attenuate public responses to risks or risk events. The human response to situations of risk, therefore, is inadequately explained by the technical concept of risk probability and magnitude.

A structural description of the social amplification of risk is presented, founded largely on the basics of the risk communication process. Amplification is shown to occur at two stages in this process: 1) during the transfer of risk information, and 2) in the response mechanisms of those receiving the risk information. In the former, the nature of amplification is exhibited by both the transmitter and the receiver of risk information. Risk signals are processed by both individual and social amplification stations, including the technical professional communicating the risk information, the news media, public agencies, social organizations, etc. Attitudes, cultural, and sociological perspectives define the degree of amplification/attenuation of the perceived risk.

The response to risk information involves the social, institutional, and cultural contexts in which the information is interpreted, its meaning diagnosed, and values attached. The authors identify four major pathways of risk response mechanisms including:

- Heuristics and values, in which individuals cannot deal with the full complexity and frequency of risk, and therefore apply simplifying mechanisms when evaluating risks and shaping responses.

- Social group relationships, which determine how focal risk issues become in the political agendas of various social and political groups.

- Signal values, which initiate a process whereby the significance of a risk event is examined.

- Stigmatization, which affects how negatively (and subsequently how seriously) a particular risk event is viewed.

These major pathways are crucial to an understanding of the social modification of risks from their technical definition to their socio-cultural manifestations of perceived risk. Such an understanding, in turn, is meaningful since the technical concept of risk is too narrow and ambiguous to serve as the crucial yardstick for policy making. The investigation of risks is both a scientific activity and an expression of culture.

53

Kates, Robert W. (1962). Hazard and Choice Perception in Flood Plain Management. Department of Geography Research Paper #78, Chicago: University of Chicago Press.

Key Words: Flood control, flood plain occupance, uncertain environment, "bounded rational man", public and individual perceptions of risk, public behavior under risk, analytical methods.

In this paper, the author discusses peoples' perceptions of risks and opportunities in the uncertain environment, and the significance of their decisions on resource management in urban flood situations. A specific examination of human occupance of flood plains demonstrated that greater flood control has resulted in increased rather than decreased flood damages.

Examining alternative courses of action in flood plain occupance, four assumptions were made concerning human choice: 1) the underlying view of man's rationality, 2) the type of decision processes involved, 3) the conditions of knowledge under which choice is made, and 4) the criteria that are used to guide such choice. Considering these assumptions along side studies of attitudes, knowledge, social characteristics, flood problems, and land use in flood plains, the author demonstrated that:

1) The major factors affecting flood hazard interpretation and evaluation include:

   - flood knowledge
   - education
   - length of time at the site

2) The perception and adoption of alternative flood damage reduction measures include:

- bearing the loss
- emergency action
- structural changes and land elevation
- changing land use
- flood control and abatement

When selecting alternatives in flood plain occupance, flood plain managers embraced the characteristics of the "bounded rational man" who is limited by experience and knowledge. Their decisions, therefore, displayed less than optimum behavior. As a result, the sole dependence on rational descriptions of human decision making in risk planning is discredited. To achieve a better understanding of risk perception and analysis the author suggests that the psychological characteristics of decision makers also be explored. Planners, therefore, should be cautious not to rely only on rational choice theory in risk planning.

54

Kates, R. W. (1986). Managing technical hazards: Success, strain, and surprise. In National Academy of Engineering, Hazards: Technology and fairness (pp. 206-220). Washington DC: National Academy Press.

Key Words: Public perceptions of risk, decision makers' attitudes toward risk, management of risks related to hazards, all planning areas.

This article discusses past approaches to hazard management as well as current challenges related to such management. Almost all hazards are regulated today. However, controversy remains regarding the social cost, implementation and enforceability of hazard regulations.

A study by Tuller et al. in 1979 indicated that the costs associated with coping with hazards in the United States was approximately 7 and 12 percent of the GNP. Approximately half of these funds were devoted to hazard management and the remaining portion were appropriated in response to damages to people, structures and the environment. Society as a whole cannot reduce the risk of any hazard to zero, but costs associated with hazard management may be reduced by minimizing the ponderous institutional safety net. The effectiveness of enforcing compliance with a set legislative standards is doubtful. The judicial branch's ability to deter negligence and compensate efficiently and justly for injury is even more doubtful.

Efforts to control hazards may eliminate some problems, but contribute to other negative effects. For example, 25 years ago efforts were made to reduce riverine flood hazard in the United States. While the frequency and magnitude of floods was reduced, the development of floodplains was encouraged, resulting in increased damages from floods. Single-fixes may lead to other problems later in the chain of causation. A spectrum of fixes, both behavioral and technological, inserted at several points along the chain lead to well-managed hazards. Focusing

on a single ethic should be avoided as much as focusing on a single-fix; the risks and benefits should be distributed fairly.

In 1984, a natural gas disaster at San Juan Ixhuatepec, Mexico destroyed a community. With the government and the associated corporation's assistance, the community was rebuilt, the homeless received accommodations, and victims received compensation. Such a rapid, efficient, and immediate response to aid victims of disaster may be a preferred replacement to the current judicial process which may be acceptable, but extremely slow.

55

Kates, R. W., & Kasperson, J. X. (1983). Comparative risk analysis of technological hazards (a review). Proceedings of the National Academy of Science, 80, 7027-7038.

Key Words: Public perception of risk, risk assessment, all planning areas, all planning steps.

This article discusses the increased interest in the field of risk and presents a review of 54 books and monographs (published between 1970 and 1983), regarding risks and hazards related to technology. The paper also addresses various categories of risk in each book reviewed. The list of categories includes: 1) overview of the field of risk; 2) risk estimation; 3) acceptable levels of risk; 4) perception of risk; 5) risk regulation; 6) case studies of risk; and 7) an agenda for research. Suggestions of the ways in which science can enlighten the study and inform the management of technological hazards are also discussed.

Polls indicate that public concern regarding technological risk and support for protection of environmental quality have been increasing despite economic recession and a "national antiregulatory climate." This trend may be explained by an increasing awareness of hazards, expanded media coverage and the public's declining confidence in risk management and institutions involved in risk management. One poll indicated that three out of four Americans agreed that life is more risky now than 20 years ago, however Americans also believe that in the next 20 years the benefits of technology will outweigh the risks.

Science can make a unique contribution to the study of hazard management by: 1) using basic science to uproot the causes of a specific hazard; 2) using scientific theory, analog, and experimentation to identify hazards; 3) establishing conventions, handling cumulative uncertainty and presenting uncertainty to non-experts; 4) setting risk estimates into comparative contexts, studying the process of risk evaluation, participating in societal judgements as knowledgeable individuals; and 5) broadening our understanding of the range of possible actions and providing improved tools for evaluation of success.

56

Kunreuther, Howard, and Slovic, Paul. (1978). Economics, Psychology, and Protective Behavior. American Economic Review, 68(2), 64-69.

Key Words: Consumer disinterest, disaster insurance, public and individual perceptions of risk, decision makers' attitudes toward risk, public behavior under risks, analytical methods, all planning areas.

This article examines the need for integrating the economic and psychological approaches to assessing public preferences when formulating policies for dealing with risks. Policy decisions regarding risks must ultimately consider both what people say they want and what their market behavior implies they want with regard to protection from natural and technological hazards. Currently, systematic empirical investigations, devoid of considerations of how people think about risk and uncertainty, are the norm in risk policy formulation.

As a basis for this study, the authors examined the critical factors influencing the voluntary purchase of insurance against natural hazards. Their research methods consisted of a field study of homeowners in hazard-prone areas, and laboratory experiments in which relevant variables could be manipulated. The field study, which consisted of face-to-face interviews of 3061 homeowners living in flood-prone and earthquake-prone areas in the United States, showed that only half of the interviewees were insured against hazards. This resulted from a number of conditions, typically involving a lack of information, or inaccurate information regarding either the availability or terms of insurance coverage, or the probability or potential damage from a future disaster. The authors found these conditions convincingly indicative of apathy or indifference on the part of the homeowners.

In the laboratory experiments, subjects were presented with a series of gambles in which certain available insurance policies coincided with specified probabilities of losing a given amount of money. In these experiments, subjects considered well-defined insurance problems without real stakes at risk. The results of the experiments consistently showed that the majority of people preferred to insure against high-probability, low-loss hazards, rejecting insurance in low-probability, high-loss situations. These results refute certain well-known economic theories which assume risk-averse individuals should desire an insurance policy which would protect them from rare catastrophic losses which they could not bear themselves. Instead, the results indicated peoples' disinclination to concern themselves with low-probability hazards.

From the results of both studies, the authors concluded that the failure of the disaster insurance market resulted primarily from disinterest on the part of consumers. Such disinterest, they add, has not been adequately investigated in the past, despite the certainty that it will continue to color risk perception in the future. In light of this, they recommend a synthesis of the economic and psychological approaches to risk analysis to make them complementary rather than competitive. For planners, these findings may be of particular interest, implying the need to consider peoples' attitudes and information processing limitations when formulating risk control policies.

57

Kunreuther, H. , Linnerooth, J. and Vaupel, J.W. (1984). A Decision-Process Perspective on Risk and Policy Analysis. Management Science, 30(4), 475-485.

Key Words: Decision-maker's attitude towards risk, all planning areas, all planning steps, risk analysis, policy analysis, decision process, low probability event.

Important issues surrounding risk analysis and policy analysis from a total decision-process perspective (all interested parties participate in the process) are surveyed in this article. Siting of hazardous, or otherwise controversial, facilities are a result of conflict resolution between various interested parties with different objectives and concerns. Because of the many different approaches that can be taken in risk analysis, outcomes on a single issue can vary or even conflict. When several parties have differing risk analyses, decision making becomes even more difficult. Suggestions for resolving conflicting agendas and conflicting risk assessments are presented.

This discussion centers around a case study of the siting of a liquified natural gas facility. Three areas of the decision process are presented with actual applications: 1) general features of the decision process found in most siting controversies; 2) the role of risk analysis in siting decisions; and 3) policy analysis in risk related conflict negotiation and mitigation.

Several interested parties with unique agendas commonly have input on the siting of hazardous facilities. This often blurs the issues at hand through inevitable inclusion of non-pertinent issues. The order in which sub-issues are addressed can affect the outcome due to the reliance of one sub-issue to another. Also, exogenous events (actual related disasters) can sway public attitudes towards the sub-issue that is on the table.

The author believes that risk of low-probability events cannot be empirically derived because of the subjective nature of many scientific decisions. In fact, often times a "scientific" risk estimate can be made only to be compared to a different "scientific" estimate (thus, the "myth of objectivity" is illustrated). Unfortunately, these types of empirical analyses are exploited to support specified interests. One reformatory measure would be to specify a set of risk analysis techniques or rules to be used in legal proceedings and other negotiations.

Conflict surrounding risk-related siting issues can be creatively managed through compensatory measures. For example, a nuclear power plant could provide electricity at reduced rates to those living in risk-prone proximity -- the "winner" pays the "loser". By virtue of the fact that some parties will incur risk, proper compensation can be made to create a more palatable situation.

Though this was more of a discussion paper versus a research project, the scope of this article was clearly defined and the outlined objectives were met. It provides pertinent case study examples which the decision-maker can use during each of the planning steps for each planning area, though the emphasis of the article was hazardous waste. The authors recommendation of

a specified set of risk analysis techniques shows good intent, but the actual formulation of the techniques should be left to the scientific community.

58

Lagasse, P.F., Schall, J.D., & Peterson, M. (1985). Erosion risk analysis for a southwestern arroyo. Journal of Urban Planning and Development., 111(1), 10-24.

Key Words: Flood control, erosion, arroyos, decision makers' attitudes toward risk, all planning steps.

This article describes the process of using erosion risk analysis in establishing flooding and erosion buffer zones along arroyos in urban areas. The model is based on the concepts of hydrologic risk. The authors also make extensive use of the Corps of Engineer's calculation technique, HEC-2. The erosion risk analysis model was applied using HEC-2 to an urban arroyo system in Bernallilo County, New Mexico.

Flood and erosion buffer zones are based on either: 1) the boundaries of a 100-year flood; or 2) the cumulative erosion from smaller floods over a twenty-five year period. The one with the larger boundary is then chosen. Erosion risk analysis contains four phases: 1) gather quantitative and qualitative data on the arroyo; 2) determine hydrographs for a range of flows; and select a design event for a long-term erosion analysis; 3) determine sediment transport characteristics of the arroyo; and 4) delineate erosion boundaries along the arroyo.

A point of significance is the authors' use of the Army Corps of Engineer's water-surface profile calculation technique, or HEC-2. It is used extensively during the model's analysis of hydrologic conditions and sediment transport, thus playing a key part in the establishment of erosion buffer zones.

The erosion risk model was used to evaluate Calabacillas Arroyo near Albuquerque, New Mexico. After its application it was found that 150 residential lots could be seriously affected by erosion along the arroyo; 70 of these lots were in the 100-year flood plain, and 53 were in the 100- year floodway. Federal Emergency Management Agency guidelines would not permit any land development on the 53 lots due to the future risk of damage from flood and erosion.

59

Langowski, J. F., Dziegielewski, B., Ferrill-Dillard, R., & Cochrane, H. C. (1987). Emergency water planning for natural and man-made emergencies: An analytical bibliography (Contract No. DACW72-84-C-0004). Fort Belvoir, VA: Institute of Water Resources.

Key Words: Emergency water supply planning, earthquakes, floods, hazardous material spills, all planning steps.

This report was created to identify and evaluate work (performed from 1945 to 1986) concerning planning for emergency water supplies in the event of a major disaster. A total of 133 annotations are included in this bibliography. All areas of emergency water preparedness are addressed. All identifiable federal and state laws and regulations related to emergency water planning have been compiled and summarized in this report. Finally, this report discusses how the Great Alaska Earthquake of 1964 affected water supply, and describes the equipment supplies, materials, and services necessary for water system preparedness and recovery.

Forty-eight publications annotated in this bibliography are case studies of both natural and man-made emergencies. The rest essentially provide emergency planning guidelines. At the federal and state level, the guidelines emphasize establishment of legal authority for emergency disaster response. At the local and utility level, emphasis is placed on the development of effective emergency operations plans for efficient recovery from disasters. Principal elements of such plans include: 1) establishing emergency communications; 2) training of the personnel; 3) preparedness through strengthening of various physical components of the system; and 4) preparation of formal written plans.

Federal laws concerning emergency water supply planning can be categorized into five sections:

1) General natural disaster laws - For example, the Disaster Relief and Assistance Act of 1974 provides a national policy for coping with all types of national disasters and outlines response responsibilities for federal departments and agencies.

2) National security orders and directives - When water emergencies impact the entire nation, particularly under circumstances affecting security, the Secretary of the Army bears responsibility for management, control, allocation, and use of water from all U.S. sources.

3) Flood control acts - These acts guide mitigation planning by establishing intergovernmental hazard mitigation teams which can be activated immediately in the event of a flood.

4) Water quality hazard legislation - This legislation addresses preparedness, response, and recovery phases and authorizes the EPA to provide guidelines for

the enforcement of water quality standards through court actions and emergency response requirements.

5) Drought hazard laws and assistance programs - Under drought hazard laws, the Army Corps of Engineers is authorized to administer emergency well drilling and transportation of emergency water for human and livestock consumption.

Findings of this study indicate a 'lack of authorized or directed mitigation and prevention actions' in all of the categories of federal hazard laws. The federal government expects state and local governing bodies to develop appropriate measures. The authors found that many state require emergency water plans at the regional or local level. Such plans, however, do not appear to be 'widely available' at the district, community, or utility levels.

After the Great Earthquake of 1964, the Anchorage utility adopted a formal disaster plan. Critical recommendations for emergency operations at the utility level involve: 1) maintenance of independent backup generators and the equipment for prompt testing of water quality; 2) the development of interagency coordination between utilities and emergency services such as phone and electric service; 3) the need to conduct emergency training of personnel; 4) advanced assignment of specific emergency tasks to alleviate frequent communication breakdowns.

60

Leiss, W. (1989). Applying risk communication and risk perception research to the understanding of disagreements about risks. Risk Abstracts, 6(4), 179-186.

Key Words: Public behavior under risk, public perception of risk, difference in public attitudes regarding risk of natural and man-made hazards, all planning areas, all planning steps, risk communication.

This article attempts to address several "practical problems" including efforts to alter people's behavior (such as smoking), and attitudes (such as nuclear power) through risk communication. The author's objective is to provide some suggestions for direct approaches to applying new information regarding risk communication and risk perception as a means to address "practical problems," including changing behavior and changing attitudes related to risk.

There are two distinctly different types of bases on which risk communication may be founded. The first type of risk/benefit trade-off situation involves both voluntary and involuntary activities such as driving or exposure to air pollution. Since activities in this category tend to be underestimated by the intuitive judgement of the public, public health officials often assume responsibility for informing the public of the related risks. The second type of risk/benefit trade-off situation also involves voluntary and involuntary activities, but people tend to downplay the benefits and perceive risks to be greater than most expert estimations. Items that fit into this second category includes controversial technologies such as pesticides and nuclear power. Consequently, much of the risk communication related to these technologies attempts to alter people's perceived cost/benefit evaluation of these technologies.

The author asserts that the communicators of these risks should be entirely open about their intentions. It is more effective for the experts to avoid attempting to shift public opinion, rather than to provide points of clarity regarding the risk/benefit tradeoffs in the situation.

An organization's credibility will be increased significantly if it is open about its goals. For example, if its aim is to change public perception of the risks of nuclear power, it should be so stated. Each interest group is entitled to their opinion. By allowing for open information exchange, the public is aided in making decisions about acceptable levels of risk. For example, perhaps the public would rather opt for a rigorous energy conservation effort, employing several new technologies which utilize reduced levels of energy than construct a nuclear power plant to supplement their energy needs. The public deserves a broad and balanced presentation of the views enabling them with the opportunity to arrive at their own evaluation of risk/benefit tradeoffs.

Several studies have examined people's perceptions regarding the costs of risk, but additional research regarding people's perceptions of the benefits from risk is needed. Further research is also needed regarding the thinking processes persons utilize when making tradeoffs between benefits and risks related to technologies. Without this additional research, a valid cost/benefit comparison cannot be made.

This article may be useful to water resource planners by providing insight into public perception of risk as well as people's behavior under risk, particularly in situations where the experts and the general public conflict in their perceptions of potential risks.

61

Lence, B. J., Eheart, J. W., & Brill, E. D. Jr. (1990). Risk equivalent seasonal discharge programs for multidischarger streams. Journal of Water Resources Planning and Management, 116(2), 170-186.

Key Words: Natural ecosystem problems, seasonal waste discharge programs, all risk perspectives, all planning steps, analytical methods.

This article introduces an approach for designing seasonal waste discharge programs for river basins with several dischargers and illustrates the approach through the control of biochemical oxygen demand (BOD). Two waste load allocation programs are presented as surrogates for minimizing the seasonally varying waste treatment effort: 1) minimum average uniform treatment allocation; and 2) maximum total discharge allocation. Seasonal waste discharge programs meet risk equivalent criteria, which require the risk of violating water standards in seasonal programs to be the same as the risks of comparable, traditional nonseasonal programs. According to simulations, including the two-season, Willamette River Basin example presented in this paper, either of these seasonal allocation programs also produce more cost savings than comparable, traditional non-seasonal programs.

In the approach presented, the risk of violating water quality is defined as the probability of incurring one or more water quality violations in any given year. The seasonal waste effluent rates of the dischargers are designed to maintain a specified level of risk while minimizing the total waste treatment effort of the dischargers. The minimum average uniform treatment seasonal discharge approach minimizes the annual average percent of removal, resulting in a limited number of water quality violations. In the maximum total discharge program, the total design waste load in each season (i.e., sum of waste loads for the individual dischargers) is determined so that total discharge over all seasons is maximized resulting in limited water quality violations.

The results presented for the Willamette River Basin indicate that either the maximum total discharge allocation or the uniform treatment allocation program would be significantly less costly than a nonseasonal discharge program. Yet, in the case of the Willamette River Basin, the seasonal uniform treatment program proved to be the most cost effective alternative. In addition, the findings indicate that cost savings rise with increases in the required water quality level. For example, if the dissolved oxygen (DO) standard is 5.0 mg/L the daily average waste discharge is the same for all four of the programs considered. However, considering a DO standard of 7.5 mg/L the average daily waste discharge differ by 66,500 lb/day (30,299 kg/d).

The seasonal approach illustrated in this paper can be used in the evaluation of several management options including variations in the: 1) number and length of seasons; 2) level of risk of water quality violation; 3) water quality standard in each season and at any point in the stream; and 4) limits on the allowable discharge at a given time. One disadvantage to seasonal programs is the overall increase in the total mass of pollutant discharged resulting in a somewhat higher level of environmental damage. Yet, in consideration of the potential cost savings, the author suggests additional research should be focused on the development of measures accounting for environmental damage so they may be included in the design of seasonal programs.

62

Lichtenstein, S., Fischhoff, B., & Phillips, L. (1982). Calibration of probabilities: The state of the art to 1980. In Judgment Under Uncertainty: Heuristics and Biases, P. Slovic and A. Tversky, eds. New York: Cambridge University Press.

Key Words: Public perceptions of risk, public behavior under risk.

This chapter is a literature review about overconfidence and its calibration. The chapter discusses techniques for calibrating the responses and states that calibration is possible.

This authors of this chapter conducted a literature review and divided into two sections: 1) past studies; 2) calibration of study findings. In the first section of this chapter the referenced studies were all conducted in a manner where a person is asked a question or given a problem to solve, and then further asked to quantify the possible validity of their response, thus

measuring their level of confidence. The second section then explains attempts at calibration of the responses.

The reviewed materials found that overconfidence was very prevalent in general-knowledge items of moderate or extreme difficulty. The article also states that each calibration case is unique and therefore there is no panacea for calibration.

63

Lund, J. R., (1990). Scheduling maintenance dredging on a single reach with uncertainty. Journal of Waterway, Port, Coastal and Ocean Engineering, 116(2), 211-231.

Key Words: Advance maintenance dredging, dredge scheduling techniques, all planning steps.

This article presents new methods for the use of advance maintenance dredging based on economic and reliability analysis. Use of advance maintenance dredging in the scheduling of dredging operations can reduce dredging costs and lessen the risk of sediment encroachment into navigational channels. Application of this scheduling technique is limited to dredging on a single reach where the distribution of sediment is known. For constant deposition rates, scheduling is achieved by using deterministic sedimentation rates. When deposition is not constant but can be described probabilistically, stochastic deposition rates are used.

Advance maintenance dredging is a new technique where more material is dredged from the channel in each dredging episode than is required to accommodate navigation. When sedimentation rates in the reach are known the frequency of dredging is reduced, thus minimizing the high start-up costs of channel dredging. Scheduling with deterministic sedimentation rates is achieved by minimizing the cost objective, which is characterized mathematically as the discounted sum of each scheduled dredging episode over a specified planning horizon. Cost of a single dredging episode is assumed to be linear with respect to the volume of sediment dredged. Non-dimensional analysis of the cost-minimization function shows that advance maintenance dredging would be preferred under the following circumstances: 1) sedimentation rates are low; 2) costs of removing dredge material from the reach to the disposal site are low; 3) the fixed start-up costs of dredging are high; and 4) discount rates are low.

Three strategies for scheduling dredging under stochastic sedimentation conditions are presented:

1) Perfect Scheduling Flexibility - Dredging occurs only when sedimentation begins to encroach the navigational channel. Dredging episodes are not fixed, but the volume dredged each episode is fixed. Time for tilling a previously dredged volume becomes a random variable. The objective equation is modified to express the expected present-value cost of dredging a specific volume of sediment whenever it begins to impair the channel.

2) Limited Dredge Scheduling Flexibility - It is assumed that dredging can only be performed during a limited season each year, and some encroachment of sediment is allowed to occur. The average amount of sedimentation allowed to encroach on the channel is estimated and incorporated into the cost equation.

3) Scheduling considering cost and encroachment risk - Dredging is conducted in fixed volumes at fixed periods. A buffer is dredged outside the channel's navigational requirements, but inside the channel the area is dredged for advance maintenance purposes. When the buffer is encroached the next dredging episode clears it. A larger buffer will lower the expected proportion of time when the channel will be constricted. Construction of this buffer adds expense, however, and this creates the implicit trade-off between cost and risk.

64

MacLean, D. (1986). Social Values and the Distribution of Risk, in D. MacLean (ed.), Values at Risk. Totowa: Rowman and Allanheld, 75-93.

Key Words: Social values, sacred values, public rituals, public perceptions of risk, public behavior under risk, decision makers' attitudes toward risks, all planning areas.

This article examines the role of social values in guiding judgements about what should be the foremost considerations in setting public policies about risk and safety. The author advances the notion that policies for dealing with risks must remain sensitive to the social values which underlie risk perception and analysis.

For demonstration, the author focusses on two primary social values central to the mechanisms of both risk analysis and perception: the distribution of risks, costs, and benefits, and the value of human life. Both exemplify individual relationships within society, social structure collectively facing risks, the effects of public policies on solidarity and fellowship felt by members of society, and the nature of public policies that embrace those common values which give a society its identity. The role these values play in risk analysis is then investigated.

Social choices about risks and risk policies invariably involve trade-offs. Risk professionals will always find that certain hazards are more easily and cheaply controlled for, and different allocations of risk controlling resources will have different levels of success in risk planning. This leaves planners with choices regarding which dangers are worth attention and which resources should be employed for their control. Risk analysis is the tool with which planners can confront such choices and determine, for example, who should benefit from a risk policy and/or what value should be placed on human life for the purposes of risk planning. In this regard, the development of public risk policies becomes a function of social values and requires the consideration of the social fabric of target audiences in the risk-planning process. Planners, therefore, should create risk control policies both to protect human lives and health and to reflect the collective sentiments which give them social character.

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Male, J. W., & Cullinane, M. J. Jr. (1988). Procedure for managing contaminated dredged material. Journal of Waterway, Port, Coastal, and Ocean Engineering, 114(5), 545-564.

Key Words: Dredge material management plans, public perceptions of risk, all planning steps, analytical methods.

This article presents the Dredged Material Selection Strategy (DMASS). The DMASS process aids in the selection of appropriate means for dredging, disposal of dredged material, transport, and treatment. The resultant viable alternatives are evaluated in respect to several criteria such as, reliability, technical effectiveness, environmental impact, cost, regulatory requirements, public acceptance, safety, and practicality. DMASS aids in the identification and elimination of nonviable options early in the selection procedure, while prioritizing the remaining dredging operations options. Early elimination of unsuitable options saves resources for use later, when more detailed and costly evaluations of the more suitable options are needed.

The DMASS process involves five phases: 1) presumption of contaminant pathway; 2) confirmation of contaminant pathway; 3) alternative development and initial screening; 4) detailed evaluation and ranking; and 5) alternative selection. This paper addresses three major phases including confirmation of contaminant pathway, alternative development and screening, and detailed evaluation and ranking. These three phases represent a process which selectively screens potential disposal sites, screens available technologies, combines sites and technologies to form alternatives which are further screened to a set which can be ranked for final selection.

Care should be exercised in the display of alternatives since the process of assigning rankings involves judgements in areas of uncertainty and weights may be assigned differently by different people. An effective display of viable options informs the final decision maker of the original variations in qualifying factors such as cost, quality and safety. Some planners may decide not to display rankings. Instead, a display may simply demonstrate differing factors of each alternative. It is important to note that the weights of these factors may be subject to change with future considerations of project criteria, reviews of the reliability of the technology, or advances in technology.

DMASS was not designed to provide an actual project design, although the findings from DMASS will offer guidelines for a preliminary project design. The author suggests that personal computer programs and systems analysis may also be useful in formulating and reviewing alternatives.

66

Male, J. W., Culliane J., & Phillips, K. (1988). Managing contaminated dredged material: Application. Journal of Waterway, Port, Coastal and Ocean Engineering, 14(5), 565-581.

Key Words: Dredging and dredge disposal, all planning steps, analytical methods.

A case study of a dredging project in Commencement Bay, Tacoma, Washington is used to illustrate the proper management of contained dredged material. The Port of Tacoma dredging project was performed in five phases: 1) presumption of contaminant pathway; 2) confirmation of contaminant pathway; 3) development and initial screening of dredge management alternatives; 4) detailed evaluation and ranking of the remaining alternatives; and 5) alternative selection.

The first phase involved an analysis of the sediment in order to assess the type and extent of contamination. Characteristics of the contaminant were used to predict the effects of contamination after dredging and disposal. The contaminant was predicted to affect surface and groundwater quality should an upland or near shore disposal site be chosen.

In the second phase, the potential contaminant pathways were used in an analysis of possible disposal sites. An evaluation of potential sites was conducted using the following criteria: availability, distance, capacity, cost, and impacts on habitat. Next, compatible dredging and transport techniques were selected for each potential site.

In phase three, technology schemes that addressed contaminant pathways were assessed and linked to specific disposal sites. Examples of these schemes include: 1) lining a landfill to prevent groundwater contamination, and 2) sedimentation to remove suspended solids from site effluent.

Phase four involved a detailed evaluation of the alternatives identified in phase three. The evaluation was based on the following criteria: 1) reliability; 2) implementability and availability; 3) technical effectiveness; 4) environmental concerns; 5) safety; 6) regulatory requirements; 7) public acceptance; 8) cost; and 9) operation and maintenance. The alternatives were then ranked and displayed in a multi-criterion plot to facilitate the selection process.

Final selection of the preferred alternative occur in phase five where alternatives were reviewed based on established rankings. This selection considered two primary objectives: 1) cost minimization, and 2) maximization of a composite qualitative criterion that integrated characteristics of each alternative. Optimization of these primary objectives was accomplished using the DMASS process.

67

Meyer, M. W., & Soloman, K. A. (1984). Risk management in local communities. Policy Sciences, 16, 242-265.

Key Words: Decision makers' attitudes toward risk, all planning areas, all planning steps, risk management at all levels of government.

This article presents an overview of current practices regarding risk management at the local level of government. The results of a survey of city managers regarding their risk analysis practices are presented. Finally, the authors offer alternative methods of handling risk considering all levels of government, local, county, state and federal.

After reviewing previous research and current policies regarding risk management, the authors conducted a survey of managers responsible for risks associated with drinking water and the disposal of hazardous wastes. Only two states were involved in the survey, Oregon and California, including Multnomah, Lane, Los Angeles and Riverside counties, and the cities of Portland, Eugene, Los Angeles and Riverside. A total of 19 interviews were conducted, involving five state officials, seven officials at the county or regional level, and seven officials in cities. The risk managers were asked a series of questions regarding topics such as, the establishment of risk priorities, their level of responsibility concerning the identification of risks, the accessibility of risk information, and the degree of need for quantification of hazards for to assist decision making.

The findings from the interviews indicated a near absence of formal risk-management activities. As defined by the authors, formal risk management involves: 1) the identification of risk; 2) an analysis of the risk; 3) determine the level of acceptance; 4) development and implementation of policies; and 5) activation of a monitoring system. Respondents indicated that priorities had been established, but few were based on quantitative assessment of risk, however the state officials expressed an implicit quantitative conception of risk. Concerning the identification of new risks, the responses demonstrated that most officials surveyed were not involved in identification. The respondents were most homogenous in their answers to the statement "there is a need for additional quantification of hazards to assist decision making." Four out of five state officials strongly agreed with this statement, while four of the local officials expressed strong agreement, seven more stated they agreed, and two disagreed.

Considering these findings, five ideas regarding future risk management were presented. First, local communities might be given scientific data concerning risk in a timely manner. Second, an explicit comparison of risks in the form of cost-benefit analysis is likely to be required in the future. Third, an explicit quantification of risks and of costs of mitigation must occur. Currently, this is determined only at the federal level, it would be useful to figure how much should be done at each level. Fourth, standard federal regulations governing risk can incur substantial suboptimalities since levels of acceptable risk often differ among local communities. Loosening of federal regulations could free local managers to determine risk that is appropriate to their communities. Finally, a method of equitably distributing risk analysis

costs, particularly the cost related to the identification of new hazards as well as quantification of the associated risks is needed to insure that such activities are undertaken.

Five alternative models of risk management are proposed: 1) the present system dominated by the federal government; 2) strengthen local capacities to utilize competent professional judgement in managing diverse risks; 3) link risk managers at all levels into a network to facilitate sharing of data regarding hazards, and their associated risks; 4) place strong risk managers charged with the full spectrum of risk management activities, at the local rather than the federal level; and 5) radically decentralize risk management. Risk officials would determine risky activities (construction, transportation, etc.), then in order to be licensed to undertake risky activities, a formal risk analysis would be required. Alternative three, the network model, is the preferable option even though logistical challenges are of consideration.

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Midwest Research Institute. (1979). Earthquake risk and damage functions: An integrated preparedness and planning model applied to new madrid. Washington, D.C.: National Science Foundation.

Key Words: Earthquakes, emergency water planning, all planning steps, analytical methods.

This study attempts to develop a comprehensive understanding of the social and economic consequences of possibly damaging earthquakes in the New Madrid Seismic Zone. The objectives include the development of a simulation model so that various physical damage functions can be empirically estimated, then converted into economic damage values. A third essential component of the study is an examination of the institutional aspects related to government and community preparedness and response.

Both probabilistic and deterministic approaches were utilized in the earthquake risk analysis. In determining the physical damage functions for different types of earthquake risk receptors (populations at risk), especially for structural damages, the surface materials and ground conditions were studied. The 15-county study region was reclassified into six major categories of vulnerability. The vulnerability indexes developed were utilized as the weight factors in the physical damage function. Three categories of populations subject to earthquake risk were identified: (1) human populations (diurnal and nocturnal), (2) structures, and (3) personal property. The basic data unit was a census tract, and the aggregate level of estimation of population at risk was a county. For structural populations both the market value as assessed by county assessors and the replacement cost of new construction estimated by a structural engineer were employed to illustrate range variation.

In the development of physical damage functions, econometric techniques of linear and log-linear regressions were employed to estimate the functional relationship between physical earthquake damages, the damage ratios, and the Modified Mercalli intensity of various earthquakes occurring in the United States. This was done in conjunction with exogenous determinants such as population density, distribution of the structures, the type of construction

material, and age of the structures. A recursive model of structural damage, property damage, and human mortality and injury was constructed to illustrate the interdependent relationships among these risk receptors. Base-line data and the projected values of populations were fitted to the model to simulate quantitatively the potential damage of various earthquake risks that the study region will face from 1980 to 2030 with virtually no additional hazard mitigation action or risk reduction program implementation.

A thorough discussion of results for the New Madrid Zone is offered but not summarized herein. The researchers note that the damage results estimated in their study are much smaller than those of other investigations; conservative estimates are useful as base-line information, and the reduction of damage estimates may reflect increasing seismic awareness and adaptation. Recommendations are made that the physical damage functions be further refined and disaggregated, and that additional research be directed toward finer risk population estimation.

69

Mishalani, N. R., & Palmer, R. N. (1988). Forecast uncertainty in water supply reservoir operation. Water Resources Bulletin, 24(6), 1237-1245.

Key Words: Water supply, operational losses, forecasting, all planning steps, analytical methods.

This paper presents an approach using parametrically varied forecast periods for determining forecast uncertainty, operational losses, and forecast accuracy. The accuracy and applicability of the approach are assessed through the use of a simulation model of the Cedar and South Fork Tolt Rivers, where the system is illustrated as a single purpose reservoir supplying municipal and industrial water to the Seattle Metropolitan area. Two additional forecasting techniques, the historic mean as the forecast and the Markov forecasting scheme, are assessed for their accuracy, applicability and potential for improvement

The model utilized in this study simulates the operation of a single reservoir with a single inflow, a single outflow, and a single purpose of supplying water to the Seattle metropolitan area. Two independent variables, forecast period length, and forecast accuracy are used to evaluate their impact on operational losses resulting from water supply shortages.

The approach defines forecast uncertainty and operated the reservoir using parametrically varied forecast period lengths and forecast uncertainty levels to investigate their impact on reservoir operation. Forecast periods evaluated ranged from one to 12 months. Forecast error was determined by a normally distributed random number with zero mean and unit variance, [ϵ = N(0.1)], multiplied by the actual historic flow and by a coefficient (o) which was parametrically varied between 0 and 0.9. The value of o depicts the degree to which the noise term contributes to the prediction and thereby reflects the uncertainty in the forecast. The normally distributed random number, ϵ_j was generated for each monthly time period. For a given month j, the forecast for F_j, was determined by:

$$F_j = AF_j + \epsilon_j * o * AF_j$$

where AF_j = the actual historic flow during month j. This approach was not intended to be a "practical" forecasting scheme. Instead, its purpose was to define 'forecast uncertainty' then relate it to incremental operational losses.

The historic mean method of forecasting predicts the inflow for a month by the historic mean for that month. For a given month i, the forecast F_i is figured by:

$$F_i = u_i$$

where u_i is the mean of the historic month i. This method does not consider the spread of the historic data about their mean. The technique is most simple and could be implemented by any water supply system operator.

The Markov forecasting scheme predicts flows as the sum of the historic mean flow and a fraction of the deviation of the past month flow from its historical mean. For month i, the lag-one autoregressive Markov model predicted the flow of Fi by:

$$F_i = u_i + p_i*(o_i/o_{i-1})*(AF_{i-1}-u_{i-1})$$

where AF is the actual historic flow, and u, o, and p are the mean, standard deviation and correlation coefficient respectively.

The authors conclude that: 1) expected operational losses increased relative to forecast uncertainty; 2) the optimal forecast period is five months (June-November); 3) benefits of a forecasting technique are defined by the degree to which economic losses can be reduced by the use of the technique, such losses can be reduced up to 88 percent; 4) the mean of historic data is not recommended for the prediction of future inflows in reservoir operation; and 5) the use of the lag-one autoregressive Markov model has clear benefits since improvements of about 9 percent compared to no forecasting, were realized.

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Moncur, J. T., (1989). Drought episodes management: The role of price. Water Resources Bulletin, 25(3), 499-505.

Key Words: Water supply management under drought, water rates, water scarcity, all planning steps, analytical methods.

This article examines whether or not raising price during a drought would induce water cuts to reduce consumption. Traditionally, municipal water utilities implement temporary water restrictions to achieve water conservation goals during drought. Few utilities have attempted to manage water use by allowing the market process to operate. Furthermore, few utilities have adopted marginal cost pricing even during normal periods. If water is adequately price elastic,

some of the problems associated with restrictions may be avoided through the use of drought surcharge. A case example in Honolulu, Hawaii is developed demonstrating that a drought surcharge would induce much of the necessary conservation, particularly when used with educational publicity.

Water charges fall far below economically efficient levels in several areas of the United States because: 1) accounting practices have generally not adjusted for inflation; 2) most jurisdictions estimate price to recover the average rather than the typically higher marginal cost; 3) few utilities attempt to incorporate "scarcity rent" in water prices, except where explicit costs of purchased water rights may have included a rent element.

In 1987, the author used household level pooled time series and cross-sectional data to estimate a demand function for single-family residential customers of the Honolulu Board of Water Supply. The estimated equation is:

$$q_{it} = \underset{}{12.502} + \underset{(0.004)\ [-0.265]}{0.234\ q_{i,t-1}} - \underset{(2.364)\ [-0.345]}{20.361\ P_t} + \underset{(0.058)\ [0.080]}{0.379\ Y_{it}} - \underset{(0.161)\ [-0.026]}{0.851\ R_{it}} + \underset{(0.111)\ [0.502]}{3.204\ S_{it}} - \underset{(0.655)\ [-0.030]}{2.997\ D_t}$$

where

- q_{it} = quantity of water consumed by household i in time period t per household member (1000 gallons per two months);
- P_t = quantity charge for water ($/1000 gallons, 1967 dollars);
- Y_{it} = household income ($/1000, deflated to 1967 price level);
- R_{it} = rainfall level in area of ith household in month t;
- S_{it} = household size, persons
- D_t = restrictions, 1 if in effect, otherwise 0;
- i = index of households, i = 1..., 1281; and
- t = bimonthly billing period, January/February 1975 through November/December 1981.

The standard errors appear in parentheses below the coefficients; elasticities, measured at the sample mean, are in brackets. The price elasticity (N_{sr} = -0.265) applies to the short run. The corresponding long run price elasticity is -0.345.

The results of this equation as applied to Honolulu, suggest that price has significant potential as a drought management policy instrument when used in conjunction with education and persuasion programs. However, the si[illegible]e-family findings are clearly stronger than the aggregate data. As a result, water restrictions may be more effective for some consumers and some direct study should be made of multi-family and other customer categories to determine the benefits of individual metering. Considering the elasticities during the Honolulu shortage of 1984, the author estimates that tripling the price would have achieved a goal of 10 percent reduction in water use. In contrast, single family residential results imply that water use would have been reduced 10 percent with only a 35 percent increase in price. The difference can be explained by the mix of water uses and the effect of unmetered customers in the aggregate data group. As source-of-supply costs increase, the use of marginal price increasing comprehensive

metering, and associated servicing will become more desirable in water supply management under drought conditions as well as normal conditions.

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Montz, B. E. (1982). The effect of location on the adoption of hazard mitigation measures. Professional Geographer, 34(4), 416-423.

Key Words: Flood mitigation, flood insurance, public's exhibited behavior under risk, all planning steps.

The purpose of this article is to demonstrate how a hazard's location correlates to people's tendency to adopt hazard mitigation measures. The author presents findings from her study of 432 flood insurance policies in the urbanized area around Binghamton, New York. Two location factors are addressed: 1) people's proximity to the source of the hazard; and 2) the expected level of exposure to the hazard. Findings from related studies by Baker et al. (1976)* and Waterstone (1978)** are also discussed.

The study focused only on groups with an 8 percent or more rate of adopting flood insurance since the smaller groups were difficult to analyze statistically. No flood insurance adoption rates were greater than 24 percent in the study area.

Only about 20 percent of the residents in the 100 year floodplain adopted insurance. Approximately 13 percent of the residents in the 100-500 floodplain had insurance (significant at alpha = .001). The author attributes the low rates of flood insurance adoption in the floodplains to the requirements of the National Flood Insurance Program (NFIP). NFIP requires the adoption of flood insurance with a federally financed or insured mortgage; therefore any future home sales would obligate the buyer to purchase flood insurance. However, only two or three houses at risk have been sold since NFIP was initiated in those communities.

Other studies have attempted to identify other explanatory relationships that would indicate new planning strategies for flood mitigation. In Panama City, Baker et al. found a statistically significant relationship (significant at alpha = .0017) between vulnerability and evacuation. In Denver, Waterstone found a relationship between horizontal distance from the stream and the adoption of mitigation measures. Within the floodplain area, no such relationship exists.

The author found that measures requiring forethought were not necessarily related to location; measures such as evacuation demonstrated a stronger relationship. The author suggests that the high mobility of the American population makes such planning difficult, or people maintain an unwillingness to plan in the face of uncertainty. This reluctance may be curbed by regulations that are developed under consideration of vulnerability and the adoption of flood insurance. Residents of Binghamton were found to plan more for evacuation in the event of a flood than to moving to a location outside of the floodplain.

* Baker, E. J., Paredes, J. A., & Smith, D. D. (1976). [Interview results for FREAC] Technical paper No. 76-1 Tallahassee: Florida State University.

** Waterstone, M. (1978). Hazard mitigation behavior of floodplain residents. Natural Hazards Research Working Paper No. 35. Boulder, CO: University of Colorado.

72

Moore, R. J., Jones, D. A., & Black, K. B. (1989). Risk assessment and drought management in the Thames basin. Hydrological Sciences Journal, 34, 705-717.

Key Words: Drought, water resource system monitoring model, all planning steps, analytical methods.

This article outlines a procedure for monitoring the reliability of water supply systems during periods of drought. A key element of this procedure is a decision support system enabling water resource managers to consider the effects of alternative choices regarding resource reliability.

An important aspect of water supply operating policy is a set of demand restriction curves which are applied during periods of drought as available water supply decreases. The demand curves aid in meeting target levels of delivery under restrictions varying in frequency and severity over long periods of time. The model enables water resource managers to better understand the impact restrictions may have upon meeting water service target levels, and the appropriate times to implement such restrictions.

Historical records of daily rainfall are essential when utilizing this system to determine scenarios of future rainfall. This information is used in a rainfall-runoff model to determine daily flows. Reservoir levels are then determined through the use of a water resource simulation model.

The risk assessment procedure is implemented on a microcomputer with an "interactive menu-and-form driven decision support system." This water resources system model also allows water resource managers to input changes in the operating system as information for the current hydrological condition of the basin and information on daily natural flows becomes available. This information can be used to determine errors of the rainfall-runoff model. The model accommodates daily rainfall-runoff simulations and adjustments to be made up to 0900 hour on the current day. In addition, an automatically updated archive of hydrometric data is maintained through a real-time communication link with a second computer dedicated solely to data acquisition via telemetry.

73

Morgan, M.G., and Lave, L. (1990). Ethical Considerations in Risk Communication Practice and Research. Risk Analysis, 10(3), September, 355-358.

Key Words: Risk communication, ethical and unethical communication, public and individual perceptions of risk, decision makers' attitudes toward risk, all planning areas.

This article examines the ethics of risk communication, specifically as applied to the conveyance of risk messages from technical experts to the lay public. It warns of the dangers associated with the use of ethically questionable communication, and describes the professional commitment all risk communicators should make to insure that ethics be incorporated into the communication of risk messages, no matter how tempting it may be to achieve the desired result more easily.

The authors demonstrate how poor communication generally results from a mismatch between the objectives of the communicator and the recipient of a risk message. These mismatches most often result from actions on the part of the communicator, such as covertly disguising messages to confuse their recipients, and sending messages with selfish motivations, leaving the recipients to decipher whose benefit is at stake. On other occasions, the recipient may be looking for a more fundamental kind of guidance than that which the communicator is providing. Whatever their underlying cause, mismatches can be quite common, and often unintentional. This creates a hurdle, as the authors see it, which every risk communicator must overcome in an effort to better the risk communication process.

For this purpose, the authors suggest cautiousness on the part of professional risk communicators, claiming that successful ethical risk communication not only necessitates good intentions and a thoughtful analysis of their motivations, but a thorough understanding of the impacts and effectiveness of their messages as well. The authors recommend further that all communicators consider fully the potential impact of their messages, as well as contribute publicly to the condemnation of ethically questionable risk communication. Such an effort might help persuade all risk communicators that they have nothing to gain from unethical risk communication.

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Moser, D. A., & Stakhiv, E. Z. (1989). Risk cost evaluation of coastal protection projection with sea level rise and climate change. In Y. Y. Haimes & E. Z. Stakhiv (Eds.), Risk Analysis and Management of Natural and Man-Made Hazards (pp. 222-239). New York: American Society of Engineers.

Key Words: Coastal problems, evaluation of protective measures for climate change and sea level rise, all planning steps, analytical methods.

This article discusses how the Army Corps of Engineers would incorporate into their shore protection evaluations any future sea level rise or changes in storm frequencies resulting from global climate change. As the effects from climate change and sea level rise occur in the future, structural projects of a larger scale than those currently in place would be needed. Controversy exists concerning the amount of sea level rise and impact of climate change on storm frequency. As a result, greater reliance upon nonstructural solutions and land use controls is likely to occur.

The Corps economic evaluation principles and decision rules aid in the selection of shore protection measures. The rationale for evaluation of coastal protection projects is the same as for flood protection. Procedures for evaluation of coastal protection projects follow those outlined in *Principles and Guidelines*. In accordance with *Principles and Guidelines* a "without project condition" is compared to each proposed alternative. The economic benefit standard of "willingness to pay" incorporates prevented damage of coastal development. Considering the uncertain occurrence and intensity of storms, the analyst must adopt an evaluation framework which allows for comparison between the relatively certain project costs and the more uncertain storm damages prevented by the project. In addition, benefit/cost analysis must compare current and future dollar costs in a common unit of measurement.

With an increased potential for hazards from coastal storms and sea level rise, it is likely that shore protection strategies will change from protective measures such as groins, bulkheads, sea walls, and beach nourishment, to non-structural strategies. Non-structural measures may be more economically efficient and socially effective than additional structural protection. Land use measures would include the regulation of investments and subsidies in hazard-prone areas, and the implementation of zoning ordinances and building codes. Greater emphasis would also be placed on emergency warning systems and evacuation plans for coastal areas at risk. Implementation and administration of those measures would be the responsibility of state and local governments.

75

Novak, J. T. (1975). Planning for emergencies at water utilities. Journal of the American Water Works Association, 67, 164-166.

Key Words: Emergency water supply planning, all planning areas, analytical methods.

The article examines the process of preparing for potentially extreme water emergencies. The author reviews the basic steps of emergency plan development.

There is frequently a disparity between utility preparation for routine emergencies and utility preparation for disaster situations. While most utilities acknowledge the necessity of planning for pump failures, line breakage, and other common water emergencies, few are willing to direct financial resources toward low-frequency, high-intensity disaster preparation. It is during such disasters that water supply may be of critical importance for fire fighting or medical requirements, yet the provision of water may be difficult or impossible due to contamination, power outages, and disruptions in communication and transportation. Normal responses may become infeasible in the postdisaster period, e.g., the inability to boil contaminated water due to power losses or broken gas lines.

The range of possible disasters is so great that it is neither practical nor desirable to attempt to plan for all possible occurrences. Most disasters produce common effects, so that provision for a variety of possibilities can be achieved for low incremental costs over those of preparing for the most likely or most severe event. There are, however, certain protective measures that are disaster-specific and that should be considered in terms of the probability of a specific event. For this reason, it is recommended that several potential disasters be considered so that training and expenditures can be applied to a variety of emergencies in order to maximize results.

The author describes vulnerability analysis as an iterative process in which each element of a system is assumed to be subjected to a series of disasters and the possible effects estimated. The two elements that appear to be most vulnerable to disruption are the availability of trained personnel and the availability of power to operate treatment, pumping, and distribution facilities. Specific steps for the vulnerability analysis procedure are given, which will illustrate system weaknesses if applied to a variety of probable events. Upon completion of a vulnerability analysis, a utility may choose absolute protection, which attempts to limit the direct effects of a disaster, or protective measures to facilitate rapid postdisaster recovery. Protective measures may be "hard" or "soft." Hard measures involve expenditures for equipment or structures, while soft measures involve time and planning but require minimal equipment or construction costs. The author lists general protective measures that are applicable to any utility or emergency situation.

Guidelines for the development of an emergency operations plan are given, with an emphasis on employee preparation. Employees should be responsible for reporting to supervisors without notification, each employee should know his/her appropriate duties and supervisor, since instructions may not be immediately available; and supervisory personnel

should have detailed descriptions of their responsibilities. The use of training sessions or drills is advocated to ensure that employees are prepared and that equipment is functional. The author notes that while damage from disasters cannot be totally eliminated, emergency planning can minimize effects and limit disruption for water utilities.

The article is concise and informative, with clear guidelines to the emergency operations planning process.

76

O'Grady, K., Economics and psychology: Methodological tension interface. (Draft Report under IWR Contract "Risk Perceptions, Project Evaluation and Risk Acceptance in Water Resources Planning").

Key Words: Public's exhibited behavior under risk, decision makers' attitudes toward risk, all planning areas, all planning steps

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This article presents the methodological differences between the social science disciplines of economics and psychology in the study of human behavior. There are distinctions among their choice of models, notions of rationality, logic preference, and the legitimacy of the research observation. This report draws attention to those differences and then proceeds to criticize the descriptive capacity of the economists' theory of choice under uncertainty, the Expected Utility Theory.

Economists uphold the basic premise that the same model can be used to define rational choice as well as predict observed choice. Psychologists prefer to simply describe human behavior and avoid normalizing any model. Similarly the economist upholds substantive rationality that views the outcome of actions of a goal-oriented actor influenced by the characteristics of the surrounding environment, while the psychologist is concerned with procedural rationality, the processes that encompass action and belief. The psychologist, therefore, possesses no single model which unifies the discipline to the extent observed in economics.

The economic hypothesis that individuals seek to maximize their personal utility, is also criticized by psychologists as being reactive rather than predictive. When the economist does use it to predict, the forecast strength is more often attributable to bolstering assumptions, and not the utility maximizing assumption. Economic analysis assumes constant tastes and preferences and accepts their formation without inquiry. The psychologist views the formation of tastes and preferences as critical developmental platforms that can vary behavior. Thus, the deductive reasoning of the economist is contrasted with the inductive reasoning of the psychologist.

By criticizing the axioms of invariance, dominance, transitivity, and cancellation associated with the economists' Expected Utility Theory, the author develops some generalizations observed by psychologists that align with their criticisms when describing the

actions of decision makers facing risk. Peoples choices are influenced/biased during the acquisition and processing of information, during the response to a choice problem and during the information feedback process.

This latter discussion provides insights to the water resource planner towards understanding the effects of incoming information on the human processing system.

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O'Grady, K., Expected utility theory: Some alternatives. (Draft report under IWR Contract "Risk perceptions, project evaluation and risk acceptance in water resources planning," Leonard Shabman, Principal Investigator).

Key Words: Public behavior under risk, water supply planning, expected utility theory, Machina's triangle, regret theory, prospect, prospect Theory, independence, transitivity, dominance and invariance, rationality, analytical methods.

This report presents arguments against Expected Utility Theory as a descriptive model of human choice behavior. Three alternatives to Expected Utility Theory (EUT) are discussed; namely, Regret Theory, Prospect Theory, and modifications to EUT as proposed by Machina (1982,1987). Also, evidence of persistent and systematic violations of four substantive assumptions of EUT is illustrated by experiments undertaken by Kahneman and Tversky (1972,1987). The comparative advantages of each choice model is discussed as well.

By relaxing the independence axiom of Expected Utility Theory, which implies that indifference curves in prospect space are positively sloped, linear, and parallel to each other, Machina (1987) attempts to reconcile the descriptive properties of EUT with observed inconsistent choice behavior as found by Kahneman and Tversky (1972). This is done by proposing a "fanning out" hypothesis which suggests that inconsistencies in choice behavior arise when individual preference functions are non-linear in probabilities.

Observed violations of the transitivity property of choice models has led to the development of Regret Theory (Loomis and Sugden,1982). An experiment conducted by Tversky suggests that individuals choose on the basis of the dimension of the "gamble" as opposed to choosing on the basis of expected "winnings", which is a clear violation of the EUT assumption of transitivity. In Regret Theory, violations of transitivity are explained as rational optimizing behavior. The Theory holds that individuals maximize a modified expected utility function where utility becomes a function of the difference between what is and what might have been. Regret Theory can be seen as consistent with those modifications to EUT as explored by Machina (1982,1987).

Kahneman and Tversky (1987) point out the observed violations of the invariance and dominance axioms of EUT which simply state that a choice between prospects is unaffected by the manner in which the prospects are described, and that if one prospect is better than another prospect in one state of the world and at least as good in all other states, the former option will

dominate the latter and will be chosen. To deal with these violations, as well as the violations of the independence assumption, Kahneman and Tversky (1987) developed what is known as Prospect Theory. Whereas EUT insists that the utility derived from an outcome is weighted by the probability of the occurrence, Prospect Theory maintains that the value associated with an outcome is weighted by a "decision weight" which is a function of the probability associated with an outcome. The value function of Prospect Theory, which is analogous to the utility function of EUT, measures the value of a prospect over the domain of gains and losses relative to a reference point, rather than over the domain of an absolute measure of wealth as in EUT. This helps explain why individuals are observed to be risk averse in the domain of gains and risk seekers in the domain of losses, and why people are more extreme in their response to losses than in response to gains.

78

O'Riordan, T. (1983). The Cognitive and Political Dimension of Risk Analysis. Environmental Psychology, 3, 345-354.

Key Words: Public and individual perceptions of risk, public behavior under risk, all planning areas.

In this article the author reviews several risk-related studies in an effort to determine why risk has become such a potent environmental issue in recent years. Through these reviews, he draws several conclusions, which he eventually uses as the basis for an explanation.

The articles reviewed demonstrated that:

- Risk and culture intertwine, leaving the selection of dangers worth attention dependent on the strength and direction of social criticism.
- Fact and value interconnect, with risky situations providing an enhanced setting for the conflicts over the compatibility of value positions and scientific "facts."
- There exists no publicly acceptable means of linking scientific judgement with political determination, leaving risk as an avenue for political dissent and for misgivings about the legitimacy of modern democratic governments.
- How people perceive and estimate risks seldom has a clear connection to their political beliefs or their views regarding political institutions.
- Current environmental concerns (CO_2 induced atmospheric warming, ozone depletion, acid rain, etc.) make the distribution of risks more "fair," striking fear in the wealthy and powerful as well as the powerless and poor.
- The existence of scientists who work outside official research establishments and who are not members of official scientific committees (counter-establishment

scientists) has divided scientific thought and exposed it to public misgiving and political doubt.

- The public alarm and political significance associated with environmental martyrdom, or the tragedy and misfortune experienced by those who die or are injured in risky situations, provides good media material.

These conclusions describe a changing political climate which reflects greater public anxieties about the future. These anxieties are expressed in a number of ways, with risk being one of the most convenient.

79

Palmer, R. N., & Holmes, K. J. (1988). Operational guidance during droughts: Expert system approach. Journal of Water Resources Planning and Management, 114, 647-666.

Key Words: Drought, expert system, all planning steps, analytical methods.

This article explains the development and implementation of a computer-based support system used by the Seattle Water Department (SWD) to assist managers in making decisions under drought conditions. The expert system (called SID) was utilized by SWD water managers during Seattle's drought of 1987, the worst drought on record for the area. Use of the SID system improved the decision makers' understanding of the significance of the drought of 1987 and its severity in relation to previous events.

The SID system utilizes an expert system, a linear programming model, database management tools, and computer graphics. The expert system allows decision makers to incorporate their intuition and experience into operating policies. Expert systems use facts and rules in an effort to imitate the process humans use to solve problems. The expert system can provide both quantitative and qualitative information which aids decision makers in the development of consistent and rational drought policies.

Primary output is a one-week operating policy. Because of rapidly changing climatic conditions, rigid, long-term policies are unwise. Past streamflow data are used as surrogates for potential future inflows. Physical and operational constraints are used to optimize two objectives: 1) to maximize system yield; and 2) to minimize economic loss. A rule base was developed to capture the more subjective aspects of system operation and to present the results in a fashion meaningful to system managers. Interviews with SWD personnel aided in the development of a structured, logical development of operating rules based upon time of year, storage levels, system demand, predicted supplies, and current restriction level.

80

Paté-Cornell, M. E. (1989). Warning systems in risk management: The benefits of monitoring. In Y. Y. Haimes & E. Z. Stakhiv (Eds.), Risk Analysis and Management of Natural and Man-Made Hazards (pp. 253-267). New York: American Society of Engineers.

Key Words: Warning systems, dam safety, all risk perspectives, all planning steps, analytical methods.

The purpose of this article is to present and illustrate a method which enables probabilistic evaluation and optimization of warning systems. This method includes assessment of inputs from signal, human response, and consequence models. False alerts and appropriate lead time from warnings are examined in an effort to achieve optimization of the warning system by balancing sensitivity and potential false alarms. The author applies this method to the problem of monitoring dams and designing effective warning systems for them.

First, a general Bayesian model is presented to illustrate the problems of monitoring dams, particularly estimating potential losses from a failure given a specific warning system described by the quality of its signal system. The Bayesian model is used to calculate: 1) the probability of a failure; 2) potential losses which may be avoided; and 3) the proportion of casualties avoided as a result of a warning system in a dam. This model is simple, excluding potential impact from memory response or false alerts.

Following discussion of this approach, the author presents a general theory of warning systems. This theory involves analysis of factors signaling potential failure and various aspects of human response to the signals as related to the type of risk and the available lead time. The author emphasizes study of uncertainties regarding the observation of precursors of various failure modes, potential lead time, and the protectionist responses which may occur during lead time. In the situation of rare events, the memory effect is not a key element. Factors such as lead time, operator intervention and public response to warnings advising evacuation or shelter are more critical. In such a case, a simplified response model may be used to determine the public's willingness to respond to a warning. Finally, the author uses several examples such as fire alarms in a dormitory, camera monitoring in a oil refinery, and warning systems in nuclear power plants, to illustrate this general theory of warning systems.

The best warning systems are not necessarily the ones that are most sensitive, but rather maintain an effective balance between sensitivity and potential false alarms. Influences from memory response to warnings is also important to consider in the evaluation of a warning system. The model presented in this paper links improved information and an increased rate of response to develop an optimal warning system.

81

Paté-Cornell, M. E., & Tagaras, G. (1986). Risk costs for new dams: Economic analysis and effects of monitoring. Water Resources Research, 22(1), 5-14.

Key Words: Dam safety, cost-benefit analysis of dam construction, all planning steps, analytical methods.

This article presents new risk appraisal and risk cost reduction techniques for cost-benefit analysis of new dams. The authors have adopted statistical default values, derived from past statistical observations, to aide in the assessment of failure probabilities for individual dams. Risks and costs of dam failure are based on forecasts of potential costs to agricultural, residential, commercial, industrial and public property of affected area. The risks and costs of human life are also considered in this method. This method of evaluation, based on the local economy, is illustrated through three case studies of dam construction: 1) the Teton Dam in Idaho; 2) the Dickey-Lincoln School Lakes Project on upper Saint John River in Aroostook County, Maine; and 3) the Auburn Dam on the American River, upstream from Sacramento, California.

Construction of the Teton Dam was completed in 1975. After one year of operation, the dam failed killing 14 people and causing $700-900 million in property damage. The other two projects involved sequential dams. As a result, probabilities for failure were computed for failure of either dam in the sequence, as well as both dams simultaneously. Considering the authors' computed probability of failure and loss estimations, the resultant benefit-cost ratios were low enough to question construction of the dams. For example, introducing risk into the Auburn Dam cost-benefit analysis caused the benefit-cost ratio to drop from an original cost-benefit of 1.01 to 0.93 with a value of life estimated at $200,000. Estimating the value of life at $1 million, the ratio dropped further to 0.72.

Reliable warning systems can improve dam safety, even though false alerts may decrease people's confidence thereby reducing the reliability of warnings. Optimization of the warning system requires a balance between signals indicating potential failure and issuing alerts.

Including risk estimations in cost-benefit analysis of new dam construction, may demonstrate a significantly lower benefit-cost ratio. This ratio may be low enough to warrant alternatives to dam construction. Active warning systems may increase the safety of a dam, but the reliability of such a system may be decreased by false alerts.

82

Pilisuk, M., Parks, S. H., & Hawkes, G. (1987). Public perception of technological risk. The Social Science Journal, 24(4), 403-413.

Key Words: Public perceptions of risk, differences in public attitudes regarding risk of natural and man-made hazards, all planning areas, all planning steps.

A survey in three California cities was taken to assess public concern about hazards of modern technologies such as, contaminated drinking water, nuclear war, transportation of explosives, and air pollution. This article reports on the findings of the survey.

A random sample was selected from three northern California communities which were intended to be representative of a larger area. The cities are: 1) Stockton, a large agricultural city; 2) Concord, a suburban city with a good variety of socioeconomic status; and 3) Milpitas, an area with recent technological development that was a target area for malathion spraying during the infestation of the Mediterranean fruit fly in 1980. 918 people were contacted by phone, with 72 percent of that figure agreeing to participate in the self-administered survey to be mailed to them. Overall, 429 persons returned their questionnaires, 172 came from respondents in Milpitas, 153 from Stockton and 104 from Concord. Respondents were asked indicate their level of concern (from very concerned to completely unconcerned) for ten hazards.

The survey responses indicated a high level of concern about all of the risks listed. According to responses, the sample was skewed toward an upper level of socioeconomic status and underrepresents minorities as compared to California state statistics. Women were consistently more concerned than men about all of the hazards; the difference was statistically significant in seven out of the ten items. Respondents with a high level of education were *unconcerned* with about 6 out of 10 of the items queried. Most respondents received their news from television (82.6 percent watched TV news "almost everyday") or newspapers. The impact of media on public perceptions are often overstated. While the media may convince people that their community at large may be at risk to a hazard, it may not necessarily convince people that they themselves are personally at risk. University scientists were rated as the most trustworthy source of information, while 41.6 percent of the respondents expressed doubt (either "not trustworthy" or "completely untrustworthy") about the media as news source, and industry representatives associated with the hazard were viewed as the least trustworthy. Politicians were considered to be the critical agent in influencing decisions concerning risks; however, the respondents wanted university scientists and the people living in affected areas to have a greater part in these decisions.

While none of the ten hazards listed in this article are related to water resources (with the exception of contamination to drinking water), the water resource planner may be interested in noting people's perceptions toward various risks, their sources of information regarding these risks, and the varying degrees to which they trust different news and information sources.

83

Public Works. (1969). The California Water Project and earthquake engineering. Public Works, 99, 65-67.

Key Words: Earthquakes, emergency water supply planning, all planning steps.

This short article summarizes information contained in a progress report entitled "Earthquake Engineering Programs," issued as Bulletin No. 116-4 of the California Department of Water Resources prepared under the direction of Renner B. Hofmann. The article describes an attempt of the department to develop earthquake hazard and engineering criteria which would apply to the California State Water Project.

The project is likely to be subject to earthquakes of varying intensities as well as other ground movement phenomena. Aqueduct facilities cross known active faults at the surface rather than in tunnels to facilitate repairs after the earthquake. The data collected by the department were used to test conventional design procedures that were the basis for most project construction. The results have allowed the department to develop failure criteria for saturated sand based on the number of earthquake pulsations, overburden and pore pressures, and degrees of saturation, compaction, and composition. Also, a computer model was developed calculating the distribution of internal stresses in earthfill structures. One of the major findings of the research project was that, in general, structures not designed for earthquake loadings suffer more damage on soft saturated alluviums than on hard rock due to more violent vibrations of the former.

84

Renn, O. (1990). Risk perception and risk management: A review, Part I: Risk Perception. Risk Abstracts, 7(1), 1-9.

Key Words: Public perception of risk, all planning steps, all planning areas.

This article discusses the public perception of risk and the "simplified cues" or heuristic rules, which people use to assess risk. Other factors, such as social values and culture which typically influence people's perceptions of risk, are also addressed.

According to the author's findings, several studies of people from various parts of the world discovered similar factors regarding people's perceptions of risk. Some of these factors include, number of fatalities, qualitative characteristics (i.e., dread, familiarity with the risk, personal control, and equity of costs and benefits), amount of institutional control, and beliefs associated with the cause of risk. While people in general may utilize these factors, variables such as culture, and political or social views, may impact their perceptions. For example, persons highly valuing economic performance and standard of living generally perceive technological risk as less ominous than persons particularly concerned with environmental and equity issues. The author also found that technical experts' perceptions differ from public

perceptions in that the experts evaluate risk with respect to the potential number of fatalities and injuries, while the public is more concerned with qualitative factors such as dread and control.

In conclusion, an understanding of risk perception and its impact upon risk analysis is vital to risk managers. Understanding the public perception of risk and the typical technical expert's perception of risk as well as the difference between the two, will improve the risk manager's ability to evaluate and manage risk.

85

Renn, O. (1990) Risk perception and risk management: A review, Part II: Lessons for risk management. Risk Abstracts, 7(2) 1-9.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, all planning areas, all planning steps, risk communication.

This article suggests that risk managers be aware of people's perceptions of risk since elements of public perceptions may allow risk managers to improve their ability to evaluate risks. Even though there are problems inherent in public perception of risk, there are important aspects of perceived risk for managers to consider in evaluating risk and developing communication campaigns. Useful aspects of public perception are discussed.

Biases and problems of intuitive evaluation of risk should not be downplayed or ignored during the decision making process. Seven examples of problems of public risk perception that may be encountered are as follows: 1) inaccurate perception of the meaning of probabilities; 2) different meaning of risks depending on one's social or cultural group membership; 3) discrepancy between the quantitative, professional concept of risk and the public view of risk consisting of qualitative risk characteristics and perceived fairness; 4) incorporation of qualitative risk and benefit factors in risk perception; 5) desire for scientific certainty and deterministic estimates of safety; 6) fear of unfamiliar, low probability-high consequence risk sources; and 7) strong preoccupation with risk-related factors such as equity, voluntariness, and societal ability to manage and control risk sources.

Taking these problems into consideration, public perception of risk can add a larger variety of dimension and concerns to a professional risk assessment such as society's ability to cope with a rare, but catastrophic event. The qualitative aspects of public perception of risk are often ignored or "averaged out" in a quantitative assessment. Risk management can incorporate the results of risk perception studies in three ways: 1) address the concerns of the affected public and find policy options that reflect these concerns; 2) move towards the goal of minimizing the risk objective and the implicit criteria of the qualitative risk characteristics; and 3) use risk perception studies to design successful risk communication programs.

The effectiveness of a risk communication program involves both the conveyance of information and the willingness of decision makers to incorporate public concerns into the risk management plan. Communication programs should not be used to alter the public's opinion,

or the program will fail. Communication entails the willingness of both sides to learn new arguments and adjust their position accordingly.

This article is useful to water resource planners because it discusses intuitive evaluation of risk as an important planning consideration when developing risk evaluations and risk communication programs.

86

Rosenthal, M. (1983). Surviving the Johnstown, PA. flood. Journal of the American Water Works Association, 75, 390-393.

Key Words: Floods, water utility emergency planning, all planning steps.

The author describes the damages to a community water system following a major flood and offers recommendations for water utility emergency planning. A case history of the 1977 Johnstown, Pennsylvania, flood is given.

On July 19, 1977, the city of Johnstown and adjacent municipalities were hit by a reverse flood following torrential rains that dumped 12 inches of rainfall within a period of seven to eight hours. Reverse flooding entails flooding of high elevations as well as low-lying areas due to particularly intense rainfall and runoff. Weather experts estimate that the rainfall experienced in the Johnstown area occurs only once in 5,000 years. The Army Corps of Engineers had declared Johnstown a flood-free city as a result of structural improvements following the flood of 1936, and the city was completely unprepared for such a disaster. The flood virtually demolished the Greater Johnstown Water Authority's system. Of the 22,500 households served by the system, over 50 percent are supplied by a gravity system fed by five impounding reservoirs; the rest are supplied through six separate and totally independent pumping stations. The Benscreek operating station, which served as the control center for the entire system, was severely flooded and lost all telemetering and electronic control systems, all communication, electrical power, and all means of transportation. More than half of the population served was without service. The provision of temporary service to some areas required more than four weeks. Two of the five sources of supply were lost, representing 40 percent of normally available supply. Two of the six pump stations were destroyed, and electrical power losses hampered production at the surviving facilities. The utility obtained water from three adjoining water utilities by running fire hose from the other utilities' hydrants to surviving hydrants within the Johnstown system. Chlorinators were destroyed at two of Johnstown's sources of supply, and nearly all of the utility's remote control equipment was destroyed or badly damaged. Supply lines were washed out throughout the service area.

At the time of the flood, the water utility had no specific disaster plan. Based on their experiences, several recommendations are made concerning water utility preparedness. An emergency plan should automatically organize personnel into operating teams with specific functions to perform that are within the scope of each person's expertise and capability. The community health organization should be involved in the emergency planning, and plans should

include coordination of various community utilities such as water, electric, gas, and transportation. Food and beverages should be stored for employee use in preparation for long hours, isolation, and loss of area food establishments. All employees physically involved in recovery operations should have tetanus shots, although routine disaster preparation should include tetanus shots for all labor personnel. An inventory of all water sources available to a community should be maintained, with information on the quantity, quality, and location of each. Alternative sources of supply for industrial and fire-fighting purposes should be identified. Each component of a water system should be able to operate at maximum capacity for a sustained period. Provisions should be made for monitoring water supplies, treatment supplies, and equipment against chemical and biological contamination, and a testing laboratory with qualified chemists should be available. Portable water testing kits should be available in case the central lab is damaged or affected by gas or electric losses. Portable chlorinators should be maintained as well.

A dependable communication system that can function independently of local radio and telephone systems is extremely important to the recovery effort. A list detailing emergency priority allocation should be formulated so that critical water needs may be met. The distribution system should be zoned by key engineering personnel to isolate potential problem areas by operating valves. Detailed drawings of the entire transmission and distribution system should be developed, and records kept of all valve activities. Plans should be developed to assign major repairs, rebuilding, or new construction to particular firms or individuals, and managers should be familiar with the labor and equipment rates allowed by the Federal Disaster Assistance Administration. All reservoirs, intakes, and supply lines should be checked immediately after a disaster occurs, followed by an inspection of mains and large service lines. If remote control or monitoring equipment is used, provisions should be made for manual operation. An alternative power source is essential, and standby generators should be compatible throughout the system to allow use at more than one location. Prearrangements should be made for the rental or purchase of replacement vehicles, supplies, and equipment. All meters within the affected area should be tested. Sources contributing to major supplies should be checked for disruption. The public must be kept informed of problems and progress in recovery, and all restoration work should be documented in writing and through photographs.

The article is concise and informative. The author provides clear, specific emergency operations planning guidelines that are well illustrated by the experiences of the Johnstown utility.

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Rowe, W. D. (1989). Alternative risk evaluation paradigms. In Y. Y. Haimes & E. Z. Stakhiv (Eds.), Risk analysis and management of natural and man-made hazards (pp. 1-21). New York: American Society of Civil Engineers.

Key Words: Risk analysis, all planning areas, all planning steps, analytical methods.

This article presents three approaches to structuring a risk analysis project. Eight risk-analysis methods, their uses, and uncertainties are reviewed. The purpose of this article is to help planners choose risk analysis structures and methods appropriate to the project policy requirements and the data available.

Three risk-analysis structures may be helpful in managing a risk analysis project: 1) top-down; 2) bottom-up; and 3) joint. Top-down analysis of a risk situation shows whether it is possible to resolve the policy issues by a subsequent risk analysis. Bottom-up analysis of a risk situation uses all available scientific information (including uncertainties) to analyze policy and attempts to resolve policy conflicts through scientific evidence. Joint analysis of a risk situation uses only the scientific information necessary to resolve a policy decision.

Eight potential methods of risk-analysis are presented: 1) quantitative health-based; 2) qualitative health-based; 3) probabilistic; 4) consequential; 5) absolute; 6) relative risk; 7) normative; and 8) descriptive. Choice of risk analysis method depends on the depth of analysis needed and target audience. Usually a combination of the various risk assessment approaches may be needed to satisfy the problem requirements. It is important to evaluate the use of the risk assessment first and then choose the appropriate risk analysis method.

88

Russell, H. (1978). The roles of public policy and public information in mitigating disasters. For the Emergency Preparedness Project, National Governors Association. Washington, D.C.: Defense Civil Preparedness Agency.

Key Words: Emergency water supply planning, decision makers' attitudes toward risk, risk communication, public behavior under risk, all planning steps.

This document examines the role of state governments in mitigating and preventing natural and man-made disasters through public policy and public information programs. It provides definition of emergency planning concepts and nonstructural measures tied to proposed planning and coordination actions among private interests and various levels of government. A bibliography is included with frequent citations and examples of case situations where emergency management measures have been implemented.

Seven disaster trends are cited to support the growing interest in mitigation and prevention measures, such as increased incidence in man-made disasters, increase in property

losses while loss of life remains generally stable, and continued building in hazard-prone areas coupled with an apparent indifference of the potential catastrophic consequences reflected in public policy.

Following a clear presentation of definitions of hazards, disasters, potential planning methods, and selected planning actions, the author reviews the four phases of management activity (mitigation, preparedness, response, and recovery) conducted by four levels of managers (private sector; local, state, and federal governments) on behalf of all natural and man-made hazards. These components and their integrated relationships in a thorough planning process were introduced in the Comprehensive Emergency Management (CEM) program originating in the 1978 National Governors Association study of state government emergency preparedness. That report observed that although states reflect well-prepared plans and response mechanisms, recovery efforts remain unintegrated with either of these two phases and divorced from mitigation or prevention measures.

The author provides a supporting discussion of why this integration between prevention and mitigation on one hand and disaster preparedness and recovery on the other is required for emergency management. He proposes research to explore useful means for evaluating mitigation effectiveness for both natural and man-made disasters which may include resulting changes in the probability of hazard occurrence, in risk, in public awareness and involvement in mitigation and prevention measures, and, for the same hazard, a comparison between costs of mitigation and prevention with response and recovery and the term for recovery with and without *mitigation and prevention measures.*

Although this report encompasses general emergency management for all types of potential hazards, it represents an excellent perspective readily adaptable to emergency water planning.

89

Santos, S. L. (1990). Developing a risk communication strategy. Water Network News, 82(11), 45-49.

Key Words: Public perception of risk, public behavior under risk, differences in public attitudes toward natural and man-made risk, risk communication, all planning areas, all planning steps.

The purpose of this article is to provide guidelines for water utility managers to use in developing an effective risk communication program with the public. The author presents seven steps for the development of an effective risk communication program: 1) determining goals and objectives; 2) identifying of the audience and its concerns; 3) understanding of risk perception issues that will influence the audience; 4) designing risk communication messages; 5) selecting the proper communication channels; and 6) evaluating the risk-communication program.

Common goals of a risk communication program include: 1) education and information; 2) improving public understanding; 3) behavior change and protective action; 4) organizationally mandated goals; 5) legally mandated or process goals; and 6) joint problem solving and conflict resolution.

In developing a risk communication program, managers should identify their audience and understand the issues which may influence the audience. Specific geographic areas, or special interest groups may serve as a target audience. Tactics may be used to discover the audience's major areas of concern such as, interviews, telephone surveys, existing data from public information polls, informal community group meetings and "focus groups" which consist of people from target groups. Target groups can also be used as a "test audience" for risk communication messages.

Understanding how the public perceives risk is important for effective risk communication. Officials should develop an awareness of "outrage factors" which influence people's perceptions of risk. Principal outrage factors include whether the risk is perceived as: 1) voluntary or involuntary; 2) controlled by the system or controlled by the individual; 3) fair or unfair; 4) having trustworthy or untrustworthy sources; 5) natural or artificial; 6) certain or uncertain; and 7) dreaded or not dreaded. For example, risk that is voluntary, controlled by the individual, perceived to be fair and not dreaded, generally would be much more acceptable to the public than a risk bearing characteristics converse to these factors.

Risk communication messages respond to citizen concerns and present facts about: 1) the project; 2) the reasons for undertaking the project; 3) the risks or impacts; 4) the precautions that have been built into the plan; 5) the unknowns and how the organization will account for these uncertainties; and 6) the involvement of the public. These messages may be communicated through: printed material, telephone hotlines, radio/television, and outreach activities. Certain channels of communication may be more effective for different audiences, therefore risk managers should choose their channels of communication according to their target audience.

An ongoing evaluation of the risk communication message will increase its effectiveness. Principal components of an evaluation program include: audience analysis; message pretesting; assessing communicator style; and outcome analysis. Audience analysis involves the development of a clear understanding of the target audience through, public opinion polls, reviews of community news clippings, and qualitative questionnaires. Message pretesting utilizes public surveys and questionnaires to obtain feedback of risk communication materials before public distribution. Style assessments enable organization spokespersons to realize their own risk communication style, attitude, and motivational pattern. Spokespersons may learn that their approach differs from the needs of their audience; style assessments help spokespersons to properly adjust their approach. Outcome analysis tools include: meeting reaction forms; verbal communication; speech evaluation checklists; and internal observation and debriefing. These tools assess the effectiveness of the program and indicate areas for improvement.

90

Sawyer, J. (1990). Effects of risk and ambiguity on judgements of contingency relations and behavior resource allocation decisions. Organizational Behavior and Human Decision Processes, 45(1), 85-110.

Key Words: Public perceptions of risk, public behavior under risk.

This article attempts to quantify and find the reasoning behind resource allocation by an individual in a work environment, meaning "how much time is spent on a task". The authors further researched this question by the addition of ambiguities to designated tasks to expand on a theory by Naylor, Pritchard, and Ilgen (1980). Their research focused upon the allocation of time and effort towards a work task within an organization. The author extends beyond this scope to include the role of uncertainty in the allocation process.

This experiment was conducted by educating the subjects on the use of function forms and how to determine optimal resource allocations. Then assigning a pair of competitive tasks to be performed within ten hours, these task assignments were from a two by two matrix of 2(alternative tasks) X 2(levels of ambiguities). Thus giving four different combinations of decisions. The subject was given one pair of the above tasks and asked to graph the task progress versus time devoted, and to then further give this graph a 99% confidence interval, for each of the tasks, as well as writing a statement describing their decision strategy. The subjects were also asked to write a statement describing their decision strategy and to complete a postexperimental questionnaire.

In this study it was clearly found that there was a direct effect of uncertainty on allocations. The results of this study suggest that individuals will over allocate time and effort to those behaviors for which they are more certain of the behavior-to-outcome contingencies.

91

Schinzinger, R., Nyirenda, L. D., Saeb, M. & Peiravi, A. (1983). Integrity of interconnected water systems. Technical Completion Report. Davis, California: California Water Resources Center.

Key Words: Water supply planning, water system reliability models, analytical methods, all planning steps.

This report examines various theoretical and applied network theory approaches for assessing the reliability of water distribution systems. Two categories of reliability models are presented: (1) flow reliability concerned with pressure and flow rate and (2) topological reliability, which is concerned with the existence of adequate connections within the system.

The results of the sensitivity analyses showed that the parameters that affect the flow reliability include the reliabilities and capacities of individual components of the system, the topology of the network, and the flow demand.

92

Short, J. F. (1984). The social fabric at risk: Toward the social transformation of risk analysis. American Sociological Review, 49(6), 711-725.

Key Words: All perspective areas, all planning areas, all planning steps.

This article reviews the history of risk analysis and examines its relationship to sociology using examples from criminology (the author's principle field of study). Four areas focusing on the sociology of risk are addressed in this article: 1) the social context of risk; 2) the social fabric at risk; 3) the perception of risks and; 4) the role of mass media in the social construction of risks. The author asserts that the field of risk analysis has been too narrow, focusing primarily on human life and health and economic values without consideration of other valued and necessary aspects of human existence. He encourages the participation of social scientists in risk research, since sociological factors impact risk analysis, specifically in regard to people's perceptions of risk and how these perceptions impact their behavior.

Factors such as social culture, public perceptions of risk, and the media impact risk analysis. Recently, the concept of risk has gained popularity. Historically, the distribution of risk has not been equal, the less powerful and the poor faced greater risks than the wealthy and powerful. As risk awareness has increased, particularly in regard to man-made hazards, all people feel more susceptible to risk. Although technology was once associated with progress, now it is viewed as a source of hazard. Public concern over risks related to technology is high. Dependency upon the media appears relative to the public perception of risk. Risks that are rare but serious are perceived with greater concern, while some other more common risks go underestimated.

The theory of risk lacks focus and does not adequately address the impact of the media and other cultural and sociological factors, upon risk analysis. The author cites an observation from Mary Douglas who asserts that engineers expect all people to behave as they do; if they are presented with the facts clearly, they will be convinced of the riskiness or safety of a project. This naive view held by some engineers highlights the need for social science input in the field of risk assessment. While social scientists should participate in the study of risk, they must also strive to coordinate with each other as they reveal their perspectives, methods and knowledge of their disciplines. If such coordination is not achieved, the field of risk will continue to lack proper focus and inadequately address sociological aspects of risk.

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Shovlin, M. G., & Tanaka, S. S. (1990). Risk Communication in Los Angeles: A case study. Water Network News, 82(11), 40-44.

Key Words: Public perceptions of risk, public behavior under risk, risk communication, all planning areas, all planning steps.

This article describes the development of the Los Angeles Department of Water and Light's (LADWP) risk communication policy. In the past, LADWP made decisions independent of public opinion. More recently, LADWP encountered public complaints resulting from certain decisions. The authors present the construction of an aeration tower as an illustration of such complaints. In an attempt to avoid such problems in the future, LADWP adopted a "proactive" rather than "reactive" communication policy.

As the public becomes more concerned about health and safety issues, they do not believe that the decisions made by scientists and engineers reflect the best interest of the general public. In response to public opinion, LADWP began a media campaign to communicate the facts regarding the safety of residents' tap water. LADWP also created a "water complaints section" which provided on-site inspections, water sampling, and answers to consumer questions. These steps proved to be inadequate as LADWP encountered public opposition to the construction of an aeration tower. The public participated in the development of the project, but not in the process of site selection. As a result, the community in the area where the tower was to be located, actively protested the project believing that LADWP was "dumping a necessary but undesirable facility on an unsuspecting community."

LADWP has several suggestions for an effective risk communication program: 1) public involvement is needed throughout the decision making process to earn the public trust because the public realizes the difference between officials who seek their opinions and officials who are seeking their support; 2) authentic facts concerning controversial information must be distributed quickly in order to avoid the development of rumors and misinformation; 3) officials should understand that risk assessment involves a certain amount of subjectivity even on the part of experts; 4) "outrage factors" regarding hazards such as the dread of the risk, voluntary or involuntary risk, etc., should be considered in risk communication; and 5) people need an opportunity to vent their feelings on emotional issues before a rational exchange of information can proceed.

Clear, complete and honest information regarding risks and public participation in the decision making process is vital for the public to gain confidence in their water supplier, and the safety of their water.

94

Siddique, A. K., & Eusof, A. (1987). Cyclone deaths in Bangladesh, May 1985: Who was at risk? Tropical and Geographical Medicine, 39 (1), 3-8.

Key Words: Coastal storms, emergency warning systems, all perspective areas, all planning steps.

A cyclone hit several coastal islands in the Bay of Bengal in May of 1985, killing approximately 11,000 people. In June 1985, a study was performed to investigate the reasons for the high number of deaths resulting from the cyclone, since the Bangladesh Space Research and Remote Sensing Organization computer detected the formation of that cyclone approximately 36 hours before it struck the coastal islands in the Bay.

The survey data was collected between June 6-16 1985 by five, two-person teams from the International Center for Diarrhoeal Disease Research Bangladesh (ICDDR, B) who were providing emergency medical relief to cyclone victims. Surviving members of households were considered primary sources of information. As a result of the disaster situation, random sampling techniques were not utilized, and the survey instrument was not pretested. Information was not sought among households with no survivors. All the interviews took place on the islands where the ICDDR, B teams were working. The information was obtained from 93 families. Questions were asked concerning pre-cyclone family size, the number of deaths, knowledge of the impending cyclone and the source of this information, previous cyclone experience, and possession of selected items.

The islands of Urir Char and Sandwip suffered great losses from the storm. All of the interviewees from Urir Char lost their homes, while 90.6 percent from Sandwip lost their homes. Likewise, 97.2 percent of the interviewees from Urir Char lost their livestock, while 73.6 percent from Sandwip lost their livestock. The death rate in Urir Char was significantly higher than the death rate determined from the Sandwip survivors. No statistically significant difference was found for possession of a radio or advance knowledge of the cyclone. A statistically significant difference ($P < 0.001$) was found between the Sandwip interviewees who could reach a shelter in less than two hours and those from Urir Char whose shelters were two to four hours away. In addition, a significantly larger number of interviewees from Sandwip had prior experience with a cyclone.

The study concluded that those who decided to stay home rather than going to a shelter had the highest risk of death from the cyclone. Other factors positively associated with death were: 1) no information or late information of the cyclone; 2) distance to a shelter; and 3) little prior cyclone experience.

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Simmons, M. (1981). Minimizing risk of flood loss in the national flood insurance program. In Y. Y. Haimes (Ed.), Risk/benefit analysis in water resources planning and management (pp. 41-52). New York: Plenum Press.

Key Words: Flood insurance, public perception of risk, public behavior under risk, all planning steps.

This article discusses the concept of risk in the National Flood Insurance Program. Factors which influence a person's decision to purchase flood insurance are addressed. Also, the requirements which a community must implement to qualify for the National Flood Insurance Program are presented.

Flood insurance is a nonstructural tactic which can control the negative economic impact of a flood. However, when a large number of people who live in a floodplain elect not to purchase insurance, society will bear most of the costs related to flood damage, rather than the individuals who reside in the flood-plain. There are three main factors which affect a person's decision to enroll in insurance programs:

1) People who do not have adequate information on flood flows and frequencies; people who have information but don't know what it means; and people with no experience with a flood event are less likely to buy flood insurance.

2) Wealthier people buy more insurance, as do those with more education and those who are older.

3) A person who is risk-averse is more likely to buy insurance than someone who is a risk-taker.

The National Flood Insurance Program was initiated as a voluntary program in 1968. Since an insufficient number of enrollees participated (despite heavy federal subsidy), the program became essentially mandatory in 1973. Full actuarial rates which reflect the real risk of loss in a particular flood-plain location, in combination with detailed flood-plain mapping, are used to qualify interested communities for the program. Communities wishing to participate in the National Flood Insurance Program must adhere to certain land use and other regulations. These regulations are designed to minimize the potential for loss if a flood event occurs.

Simon, A. (1989). The discharge of sediment in channelized alluvial streams. Water Resources Bulletin, 25(6), 1177-1188.

Key Words: Dredging, channel evolution, sediment discharge, all planning steps, analytical methods.

This article presents the findings of a study conducted in West Tennessee to determine discharge trends of sedimentation from the Obion-Forked Deer River system to the Mississippi River. Changes in sedimentation are categorized into six stages:

I. **Premodified** - sediment transport with mild aggradation;
II. **Constructed** - removal of vegetation (?);
III. **Degradation** - basal erosion on banks;
IV. **Threshold** - basal erosion on banks;
V. **Aggradation** - development of thalweg, initial deposition of alternate bars, reworking of failed material on lower banks; and
VI. **Restabilization** - aggradation, further development of thalweg, further deposition of alternate bars, reworking of failed material, basal erosion on outside bends deposition on flood plain and bank services.

The approach to this study is empirical and utilizes process-response mechanisms that operated over time and space in channelized networks.

Three principal categories were investigated:

1) **Suspended-sediment data** - were collected during the study and a corresponding water discharge measurement was made for accurate illustrations of flow. Suspended sediment loads were calculated as tons per day by a simple conversion. Then, the data was log-transformed and analyzed by linear regression. Flow-duration curves for this study were generated from daily-mean discharges of the period of sampling and the period when the site was in a given stage of channel evolution.

2) **Bed-material discharge** - was assessed through the use of Colby's* method for estimating the bed-material discharge of sand-bed streams. Mean velocities were substituted for each discharge value obtained from the flow-duration curve thereby enabling calculation of the average annual bed-material discharge. Samples of bed-material were taken annually during low-flow condition, from 1983 to 1987, at all sites.

3) **Morphologic bed-level changes** - were expressed by a power function. The parameter 'b' was a dimensionless exponent (positive for aggradation and negative for degradation), determined by regression, and indicative of the nonlinear rate of change on the bed; therefore a plot of 'b' versus river mile served as the

model of bed-level change over time and space. Cross-sectional data was obtained from surveys and plans of the U. S. Army Corps of Engineers, U. S. Geological Survey, Soil Conservation Service, and the Obion-Forked Deer Basin Authority.

Bed-material discharges are highest at the initial phases of degradation which occur in Stage III. They decrease during Stage V as net aggradation occurs on the channel beds and banks. Suspended-sediment transport peaks during Stage IV. This decreases somewhat in Stage V, but remains relatively high in Stage VI as a result of headward migration of knickpoints in the tributaries. Eroded bed-material constitutes approximately 24 percent of the total sediment eroded. Generally, these coarse-grained sediments do not discharge from the drainage basin in large quantities, but are transferred downstream and aid in the recovery of the channel. In contrast, very little fine-grained materials are deposited on the channel banks or bed indicating that almost 400 million cubic feet of channel sediments have been delivered into the Mississippi River from the Obion-Forked Deer System over the last 20 years.

* Colby, B.R. (1964). Discharge of sands and mean-velocity relationships in sand-bed streams. [U.S. Geological Survey Professional Paper. 462-A]. Washington D.C.

97

Sims, J. H., & Baumann, D. D. (1983). Educational programs and human response to natural hazards. Environment and Behavior, 15(2), 165-189.

Key Words: Public behavior under risk, public perceptions of risk, methods to affect people's behavior, all planning areas, all planning steps, analytical methods.

This article reviews the literature concerned with those methods which effectively encourage residents to protect themselves and their property before a flood (or other natural hazard) occurs. Six issue areas are addressed: 1) education awareness; 2) experience; 3) psychological characteristics; 4) characteristics of warnings; 5) the role of authorities; and 6) imposed measures of prevention.

Educating people regarding hazards does not necessarily increase their awareness and/or change their behavior. Those education campaigns which are successful may be a result of the presence of specific conditions, such as an individual's personal experience with the hazard. However, experience may also have a negative impact on a person's behavior by leading to overconfidence and an overestimation of safety. Other factors, such as a limited capacity to process information, may also impact behavior. People want intellectual closure -- to have a decision made without changing their minds later. Generally, hazards which are considered uncommon are overestimated, while common risks are underestimated.

There exists a significant relationship between behavior and a person's attitude toward control. Those who feel in control are the ones who take precautions, while those who feel controlled by luck or fate neglect to practice precaution. Hazard warnings are also important.

According to Carter (1979), 90 percent of people will evacuate "if they are convinced of the event's seriousness" (Sims & Baumann, 1983, p. 177). Several suggestions for effective warnings were: 1) make them clear; 2) spell out the desired response; 3) an important, credible person should make the announcement; 4) reinforcement socially and locally; 5) television is more effective than radio for hazard warnings; and 6) use of positive appeal, rather than the use of threat or fear. Other options such as the imposition of laws, (ie., flood-plain zoning and mandatory flood insurance) may eliminate the question of voluntary behavior, but the costs and benefits of such actions must be considered.

This article may be useful to water resource planners as they attempt to understand the perceptions and behaviors of people when they are confronted with the risk of natural hazards. The information regarding effective and less effective methods of reaching the public through information campaigns may also be of interest.

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Sjoberg, L. (1979). Strength of belief and risk. Policy Sciences, 11, 39-57.

Key Words: Public perception of risk, all planning areas, all planning steps, subjective probability.

This article provides a review of previous studies regarding "subjective probability" (the extent to which a person believes in the occurrence of an event) and its relation to risk analysis. These are important factors in determining risk because various procedures for the analysis of risk (ie: fault trees) utilize the subjective judgement of experts in the development of data. Furthermore, society's response to potentially risky technologies is influenced by people's perceptions of risk probabilities.

Review of pertinent literature revealed some heuristic observations of subjective probability. For example, studies indicate that beliefs are distorted by people's emotions and "wishful thinking" which may cause them to adhere to faulty or skewed beliefs. People also tend to be overly confident in their judgements. Judgements regarding risk which are easy to remember or understand tend to be more realistic to people. Generally, people discount contrasting evidence after they have made a decision. In this same regard, information which is presented last or most recently before a judgement is made, tends to have the greatest influence. People's expectations also heavily influence their decisions.

Individuals tend to make similar errors in their judgements regarding risk. Consideration of these tendencies in risk analysis is important because the analysis of risk includes the use of human judgement. Consequently, much of the data used in risk analysis can be categorized as subjective probability data. Typically, risk analysis neglects the broader, long-term social affects of technology. Risk analysis also falls subject to biases, and the assessment of such probabilities is extremely difficult.

99

Slovic, P. (1986). Informing and educating the public about risk. Risk Analysis, 6(4), 403-415.

Key Words: Risk communication, public perceptions of risk, risk management, all planning areas, all planning steps.

Risk communicators must recognize and overcome problems resulting from the scientific limitations of risk assessment and the subjective judgements of people. Risk communication involves the delivery of information which is characterized by uncertainty and complexity. In order to design effective communication programs risk communicators must make themselves aware of these problems.

The terminology and techniques of scientific risk assessment vary considerably. These inconsistencies make it difficult to diffuse general concepts of risk assessment throughout the general public. In particular, communicators need to understand that risk assessments are developed through the use of theoretical models that are derived from subjective judgements and assumptions. The accuracy of the models is related to the accuracy of these judgements and assessments.

Risk communicators also need to establish an awareness concerning the limitations of the public's understanding of risk. Public perceptions of risk are 'influenced by the memorability of past events and the imaginability of future events.' As a result, significant disasters, events that receive heavy media coverage, or a vivid film, can influence and potentially distort public perceptions of risk. People also prefer to avoid consideration of uncertain risks; this attitude becomes very difficult to alter.

Communication between experts and the public often breaks down because each group has a different framework with which to perceive risk. The criteria used by the public to judge risk is different than the criteria used by experts. For example, experts' judgements of risk are highly correlated with technical estimates of fatality. In contrast, public perception of risk is based primarily on those adverse effects that are uncontrollable, dreaded, catastrophic, fatal rather than injurious, not offset by compensating benefits, and delayed in time so the risks are borne by future generations. These differences must be known by the risk communicator in order to address any public concerns.

100

Slovic, P., Fischhoff, B. (1983) How safe is safe enough? Determinants of perceived and acceptable risk. In C. Walker, L. Gould and E. Woodhouse (Eds.), Too Hot to Handle? Social and Policy Issues in the Management of Radioactive Wastes (pp. 112-150). New Haven CT: Yale University Press.

Key Words: Decision makers' attitudes toward risk, decision making techniques under risk and uncertainty, all planning areas, all planning steps, analytical methods.

This paper explores elements of risk assessment critical to the debate over nuclear power. Emphasis is placed on the following concepts: 1) participation by both the public and technical experts is necessary; 2) all judgements possess an element of subjectivity; and 3) and an understanding of proposed decision making techniques is crucial to effective hazard management.

Participation of both the public and experts is necessary in order to maintain an open and responsive decision making process. Exclusion of public input may create a new technological elite, potentially causing the public to become technically incompetent and eliminating it from a spectrum decisions.

Research indicates that people "violate principles of rational decision making when judging probabilities, making predictions, and otherwise attempting to cope with uncertainty." Utilization of heuristics (rules of thumb) contributes to this situation. Common heuristics include:

1) Availability Bias - People recall frequent, recent and/or highly emotional events better. As a result, they overestimate occurrence of these events.

2) Overconfidence - Individuals and experts possess too much confidence in the accuracy of their judgements.

3) Desire for Certainty - People have difficulty resolving risk/benefit conflicts even in simple gambles, therefore they deny their uncertainty i.e. flood-plain residents deny that a flood could occur in their area.

4) Perseverance of Beliefs - People are reluctant to change their minds after forming an opinion.

Assessment of risk is inherently subjective. In the rare instances when statistical data is available, the interpretation of such data is still subjective.

After the assessment of risk, a decision concerning the accepted level of risk must be made. Five decision making techniques are proposed:

1) Fault Trees - List all outstanding potential pathways to failure.

2) Muddling Through - Initially involves making somewhat arbitrary decisions, which later evolve into generally accepted standards. This process is basically nonanalytic.

3) Comparative Analysis - Examines acceptable levels of risk for different activities.

4) Cost-Benefit Analysis - Quantifies, in terms of dollars, estimated gains and losses from a particular activity.

5) Decision Analysis - Handles situations with several options and varied consequences. Sophisticated models of decision problems are combined with a specific theory designed to deal rationally with uncertainty and the subjectivity of decision makers' preferences.

101

Slovic, P., Fischhoff, B. & Lichtenstein, S. (1980). Facts and fears: Understanding perceived risk. In R. Schwing & W. A. Albers, Jr. (Eds.). Societal risk assessment: How safe is safe enough? (pp. 181-216). New York: Plenum Press.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, all planning areas, all planning steps.

Subjective judgements made by both the public and technical experts, play an important role in risk assessment and risk communication. Biases characteristic of lay people and experts are discussed in this paper. This article also examines public perceptions of risk through a survey conducted by the authors.

Lay people commonly rely on personal experience and observation to evaluate risks. People tend to utilize particular 'judgmental rules', otherwise known as heuristics, to simplify complex information characteristic of risks. These heuristics include:

1) Availability - People will most readily recall events that are recent or occur frequently; then they use these observations to judge other events.

2) Overconfidence - Both the technical experts and lay people are overconfident in their estimations of risk assessment.

3) Desire for certainty - People find it difficult to evaluate the risk/benefit conflicts even in simple gambles; therefore they tend to deny the presence of uncertainty.

4) It won't happen to me - People commonly believe they are 'personally immune' to the same hazards they recognize as societal risks.

5) Reconciling divergent opinions about risk - Experts and lay people have differing perceptions concerning the risk of various technologies. All people are very slow to alter their opinions even when faced with contrasting evidence.

The study utilized psychometric procedures to elicit judgements concerning perceived risk and benefits from various activities and technologies, as well as judgements regarding levels of acceptable risk. The participants in the study consisted of 76 members (and their spouses) of the League of Women Voters of Eugene, Oregon. In total, 52 women and 24 men were questioned regarding 30 different technologies and activities. For each of the 30 categories, there were questions concerning: 1) its perceived benefit to society; 2) its perceived risk; 3) the acceptability of its current level of risk; and 4) its position on each of nine dimensions of risk.

The results of the study indicated that many current activities and technologies were viewed as very risky. A consistent, but not outstanding relationship between acceptable level of risk and perceived benefit, was found. The results also indicated that where benefits were greater, greater risks would be accepted. Higher risks would be tolerated with voluntary activities as opposed to involuntary activities. Activities associated with dread and certain fatal consequences were deemed most in need of reduction. For any given level of benefit, greater risk was tolerated if that risk was voluntary, immediate, known precisely, controllable, and familiar. The study demonstrated little relationship between perceived risks and existing risks. Still, perceived risk declined slightly with overall benefit. Participants tolerated several activities which were rated with very low benefits and very high risks, such as alcoholic beverages, handguns, motorcycles, smoking. Participants also tolerated several activities perceived to have high benefits and relatively low risk such as, prescription antibiotics, railroads, and vaccinations.

102

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1981). Rating the risks. In Y. Y. Haimes (Ed.), Risk/benefit analysis in water resources planning and management (pp. 193-217). New York: Plenum Press.

Key Words: All risk perceptions, all planning areas, and all planning steps.

A survey of lay people and risk assessment experts showed differences in the way these two groups perceive risk. The lay people's risk perceptions were influenced by frequency and certainty of death, catastrophic potential, overconfidence, and a desire for certainty. The experts tended to base their perceptions on statistical evidence, such as the actual number of deaths from a particular event.

This study was based on four groups of people who rated 30 different activities and technologies according to the current risk of death from each. Three of the groups came from Eugene, Oregon, and included 30 college students, 40 members of the League of Women Voters, and 25 business and professional people who are members of the "Active Club." The fourth group included persons chosen for the study because of their professional involvement with risk assessment. The group included a geographer, an environmental policy analyst, an

economist, a lawyer, a biologist, a biochemist, and a government regulator of hazardous materials. All of these persons were asked to rank the riskiness of a person dying as a consequence of any one of the 30 activities or technologies (a score of 10 represented the least risky activity or technology). Each person was also asked to qualitatively rate the 30 hazards (on a scale of one to seven) for nine different characteristics, such as voluntariness of risk, knowledge about that risk, control over risk, newness, dread, and severity of consequences.

Study results indicate that lay persons and experts have divergent views regarding risk. The experts' opinions of risk closely align with statistical frequencies of death. In contrast, lay persons' perceptions were partially based upon death frequencies, but qualitative aspects such as dread and the possibility of fatality from the hazard also impacted their perceptions of risk. Substantial amounts of research support the concept that people are quite reluctant to change their beliefs and often remain persistent despite evidence to the contrary.

Even though lay people had difficulty accurately assessing risks, removing them from the decision making process is not suggested. Rather, the authors challenge lay-persons to: 1) become better informed; 2) rely less upon unexamined or unsupported judgements; 3) to be aware of the qualitative aspects which affect judgements; and 4) to be open to new evidence which may alter their current perceptions.

103

Slovic, P., Lichtenstein, S., & Fischhoff, B. (1984). Modeling the societal impact of fatal accidents. Management Science. 30(4), 464-474.

Key Words: Public perception of risk, differences in public attitudes regarding risk of natural and man-made hazards, risk models, all planning areas, all planning steps.

Most models of multiple-fatality accidents have stated that the societal cost of N lives lost is a function of N^{α}. Most common models, such as the α model, are not adequate in addressing risks because they neglect the social impact of an accident. The author asserts that the α model should be abandoned in favor of models that incorporate significant futuristic events and consequences likely to result from an accident.

A review of previous studies and two surveys regarding perceptions of risk were conducted. In the first survey, 21 women (the average age of the group was 37) were asked to rate the seriousness of ten hypothetical accidents such as: a dam collapse, a hundred year flood, the collision of two jumbo jets, a nuclear reactor accident, and the steering failure of a new model auto. They rated factors such as the amount of suffering and grief from the loss of life, the number of people who need to be aware of the accident through the media, and the "informativeness" of those accidents. An event is informative if the accident can yield information that was previously unknown about the activity. The second study involved 78 university students who rated 30 hazards such as dams, nuclear power, radioactive wastes, DNA technology, water chlorination, and antibiotics. The hazards received ratings based on the amount of information each provided on the probability that similar accidents would occur.

Results of the first study indicated that the amount of suffering and grief caused by an accident was closely related to the number of fatalities caused by the accident. The informativeness of an accident, rather than number of fatalities, was closely related to the perceived seriousness of the accident. The accidents which signaled increased complications in the future received higher ratings of concern and the respondents indicated a greater need for the public to be informed. The findings of the second study also indicated that the informativeness, or signal potential, of an accident is closely related to the perceived seriousness of the accident. Ratings such as dread risk and unknown risk were found to be excellent indicators of signal potential.

Familiar hazards, whose risks are well understood and are neither dreaded nor catastrophic, may carry little new information, and their social impact may be determined by the direct costs of *N* lives lost. In contrast, hazards that are less understood, involve more dread, or both, will be more powerful signals, and a simple function of *N* will not be adequate to represent their importance.

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Slovic, P. (1987). Perception of risk. Science, 236(4799), 280-285.

Key Words: Public perceptions of risk, difference in public attitudes regarding risk of natural and man-made hazards, decision makers' attitudes toward risk.

This article is a literature review of risk perceptions, from both the public's and the expert's points of view.

This article reviews literature about perceptions of risk and attempts to place them in perspective. The approach of the research cited is psychological evaluations to determine the basis of the logic behind the reactions and attitudes toward risks. A comparison of the logic behind the public and expert's perceptions of risks are presented and compared.

This article found that the public's conception of risk was broader taking more factors into account than the expert's.

The conclusion of this research was that the public's perception of risk is generally sound, if given the proper facts and information. Therefore conforming the need for risk communication and two way interaction between the public and risk management experts.

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Smith, V.K., Desvousges, W.H., Johnson, F.R., and Fisher, A. (1990). Can Public Information Programs Affect Risk Perceptions? Journal of Policy Analysis and Management, 9, 41-59.

Key words: Risk Analysis, Public and individual perceptions of risk, Public behavior under conditions of risk, public information about risks.

This article provides an evaluation of the effectiveness of different means of risk conveyance to the public. The examination utilized a study group of individuals that where already participants in a New York State Energy Research and Development Authority (NYSEDA) survey of home radon levels. Using EPA Action guidelines, which are presented in quantitative form, six different types of presentation formats were used to convey to participants the guidelines and recommended actions for radon hazards in the home. The six different formats were designed to deal with the following problems and combined or included different aspects of these approaches.

1. How does the public perceive their risk from an environmental hazard when:

    a. Purely quantitative information is provided ie. 10 pCi/l per lifetime gives a risk of death from radon exposure of 30-120/1000 deaths.

    b. Qualitative. Such as 10 pCi/l per lifetime is equivalent to the risk associated with smoking 25 cigarettes a day.

    c. Fact Sheets (one page summaries on the related risks and facts associated with radon).

    d. A combination of one or more of the preceding.

2. How do different prescriptive strategies rate in terms of action response, such as:

    a. Command format eg. strongly worded statements suggesting courses of action which must be followed.

    b. Cajole format eg. Statements toned in a manner commonly associated with informed consent requirements in medical treatments.

The authors concluded that:

- Public officials should not adopt strategies that provide minimal risk information to the public as a means of avoiding undue alarm, for this can have the reverse effect.

- Measures of the effectiveness of risk communication will depend on how education and behavior change are defined

- Categorical guidelines about risk without quantitative information can lead people to treat the levels as threshold, creating an artificial discontinuity in the response to small changes in risk perceptions.

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Stallen, P. J. M., & Tomas, A. (1984). Psychological aspects of risk: The assessment of threat control. In P. F. Ricci, L. A. Sagan, & C. G. Whipple (Eds.), Technological risk assessment (pp. 247-282). The Hague, The Netherlands: Martinus Nijhoff Publishers.

Key Words: Difference in public attitudes regarding risk of natural and man-made hazards, how people assess threatening events, technological hazards, all planning areas, all planning steps.

This article examines how individuals evaluate technological risks. Psychological analysis of the threat of a technological hazard, resultant stress, and behavior are examined. The authors find no correlation between a person's perception of risk from technology and the relative frequency or probability of negative consequences from the technology. Individuals tend to be more concerned about their control over a particular risk and estimating the uncertainty involved in their own exposure to the threat.

An event becomes threatening when the possibility of attaining one's goals and not satisfying one's needs is called into question. Stress occurs when a threat causes demands on the individual that are in conflict with the person's goals or needs. Stress can be reduced through coping mechanisms, such as: 1) exploring opportunities to alter the threat; 2) looking for ways to move away from the situation; and 3) reappraising the threat. Sometimes avoidance to escape decisional conflict occurs. Three main defensive strategies are: 1) procrastination; 2) shifting of responsibility; and 3) bolstering of the least aversive alternative.

Individuals seem to assess threat based upon the familiarity of the technology, the catastrophic potential of the technology, the need for benefits from the technology, and the distribution of benefits and damages. These aspects may be used as coping mechanisms under the stress of a technological threat. For example, those living closest to risks accept these risks more than those living farther away from them. One reason for this may be that persons living in close proximity to a hazard bolster their judgement by exaggerating the benefits related to those technologies. Perception of personal control may act to reduce feelings of insecurity concerning technological activities. An individual may perceive personal control if a certain outcome is intended, personal choice is clearly available, and if the intended outcome in fact occurs.

107

Stedinger, J., Heath, D., & Nagarwalla, N. (1989). Event tree simulation analysis for dam safety problems. In Y. Y. Haimes & E. Z. Stakhiv (Eds.), Risk analysis and management of natural and man-made hazards (pp. 305-314). New York: American Society of Engineers.

Key Words: Dam safety, flood control, event trees, all planning steps, analytical methods.

Current safety evaluations have found that several existing dams do not meet probable maximum flood (PMF) standard safety requirements, which is the current design standard for high-hazard dams. As a result, the authors propose the use of risk analysis to evaluate the need for retrofit or changes in operating policy. An event tree is used to describe the many random factors which contribute to major inflow floods.

The interest in risk analysis has risen as budgetary constraints have forced project planners to seek justification for appropriations. Risk analysis can be useful in such a situation. Risk analysis for a dam may include estimation of the costs of reducing the probability of large flood events, dam failures, and the consequences of such events. A cost-benefit analysis may then be made with respect to these risks.

Event trees aid risk analysis in estimating the probability of dam failure as well as potential damage and loss of life. Event trees illustrate the relationships among several pertinent factors such as, rainfall distribution across time, antecedent soil moisture levels, initial reservoir levels, reservoir operating policy, the seasons and time of day of the incident, and the impact of other structural failures. The event tree simulation is achieved by discretizing the random variables, being careful to capture the interdependencies when evaluating the resultant probabilities of the various discrete outcomes. The most important random variable is rainfall depth. Using Monte Carlo evaluation, the rainfall depth that causes dam failure for the values of all random variables is determined. Results of the analysis are plotted using the distribution for damage or loss of life. This reveals those probabilities associated with various thresholds, trade-offs between increased damages and increased costs, and discontinuities in the distributions. The authors suggest that PMF be replaced with an explicit risk target, or risk/cost analysis which considers quantified relative risk factors.

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Swift, R., & Baldwin, K. C. (1988). Collision tolerant pile structure hinge concepts. Journal of Waterway, Port, Coastal, and Ocean Engineering, 115(1), 125-129.

Key Words: Navigation, prevention of transportation accidents, collision tolerant pile structures, all planning steps, analytical methods.

This article introduces the benefits of replacing damaged markers with collision tolerant pile structures (CTPS) and discusses the design, testing and computer modeling techniques for

two alternative CTPS. A CTPS is a single pile with a hinge at the mudline where navigation aids can be mounted. The hinge enables the pile to flex upon impact and then be restored its original position.

One CTPS design utilizes a peripheral stay/universal joint system, the other is designed with a central stay. Both designs use pipe for the pile section and a large pretensioned spring housed axially within the pile. Application of spring force to the hinge stays provides the pile with a position restoration moment. The peripheral stay system design uses the double axis, universal joint hinge with external stays as illustrated in Figure 1. The central stay design operates as a hyper-extensible, ball-in-socket joint as depicted in Figure 2.

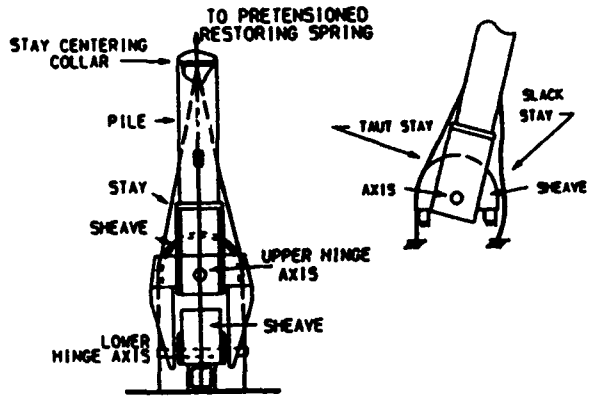

Figure 1

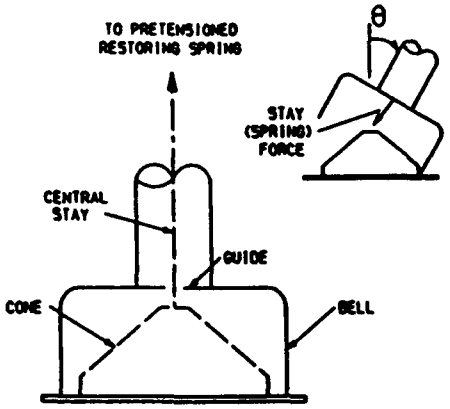

Figure 2

Testing of these designs involved laboratory experiments to evaluate the spring tension/hinge moment as a function of inclination angle. Field tests included collision-recovery experiments and measurements of wave response motion. Both designs demonstrated full recovery from every collision and met the verticality requirements under severe operating conditions.

Revised versions of the two-dimensional computer models were applied to the physical models during field test conditions. The equation used was 'the time rate of change of angular momentum equation' applied about the hinge pivot point:

$$I_H \theta = M_H + M_G + M_W + M_F + M_B$$

Where: I_H = mass moment of inertia about the hinge; θ = inclination angle; and M_H, M_G, M_W, M_F, and M_B are applied moments as a result of hinge, gravity, wind, fluid motion relative to the pile (due to steady current, waves and pile movement), and barge contact, respectively. Results of the computer model indicated minimal movement due to 0.6 m waves. Findings from the experiments depicted the same movement.

Overall, test data and computer model predictions were in agreement concerning collision, recovery, and severe wave incidents. The authors found that the central stay system 'requires a smaller spring pretension force to obtain the same or better hinge performance, has less moving parts, and the hinge is more compact.' As a result, the authors encourage further development emphasizing the central stay concept.

109

Thomas, L. (1986). Risk communication: Why we must talk about risk. Environment, 28(2), 4-5,40.

Key Words: Public perceptions of risk, public behavior under risk, decision makers' attitudes toward risk.

This article addresses the increasing problem of communication between the public and government officials about modern technological risks.

This article is taken from a speech at the National Conference on Risk Communication by Lee Thomas administrator of the U.S. Environmental Protection Agency. This article discusses the need for public officials to inform and educate the public of risk and risk related decisions. Public officials also need to gather input from the public on risk related decisions. The author considers this two way communication essential, to deal with our modern problems and concerns.

110

Thunberg, E. &, Shabman, L. (1990). Determinants of residential landowner's willingness to pay for flood hazard reduction. [Virginia Tech Contract #87-1050-02; IWR Contract #DACW-72-86-D-0012].

Key Words: Flood hazard reduction, public perceptions of risk, public's exhibited behavior under risk, people's willingness to pay for flood protection, all planning steps.

This report presents the results of a study conducted in Roanoke, Virginia, which tested the importance of property and nonproperty concerns on a landowner's willingness to pay for a flood control project. These concerns included property effects, anxiety relief, and avoidance of community disruption caused by flooding.

Located near the headwaters of the Roanoke River, Roanoke has experienced 10 floods of varying magnitude since the turn of the century. In response to flooding, the Army Corps of Engineers developed a flood control plan that combined flood walls, bridge replacements, and river channel improvements to increase the capacity of the river. This survey was administered to residents of the area along the river reach to be protected by the project. A total of 134 landowners were identified. Ninety of the landowners were interviewed by phone, but only 74 useable surveys were obtained.

Contingent Value Method (CVM) was used as the general survey-based technique. CVM is typically used to estimate benefits for changes in the availability of non-market commodities such as endangered species, air quality, and the value of recreational sites. This survey method minimizes strategic bias (respondent gives false answers in order to influence the outcome of the survey), and hypothetical bias (lack of experience with flooding consequences or flood control

measures which leads the respondent to believe that the contingent scenario will not occur). The model was specified in logarithmic form to allow for possible diminishing marginal utility.

Twenty-two of the seventy-four completed interviews "made a zero bid for reasons other than an inability to pay or that the project would provide no benefit." These interviews were eliminated from the analysis. By using Heckman's two-stage model, the authors determined that omission of the zero bids did not introduce sample selection bias.

Those variables hypothesized to influence willingness to pay for flood control (except the individual's time horizon for floodplain property ownership) are significant at the .10 level. Results indicate that participants' willingness to pay for property effects (expected personal property protection and expectations for increases in property values) and nonproperty effects (anxiety relief and reductions in community disruption) were positively related to willingness to pay for project construction. Income was also positively related to willingness to pay. Evaluated at sample means, the predicted willingness to pay for a landowner that did not purchase flood control insurance would be $188.63. The predicted willingness to pay for an individual that did purchase flood control insurance is $36.01. As a result, flood insurance appears to serve as a substitute for structural flood protection. The variable with the greatest impact on willingness to pay was community effects.

111

Tversky, A., and Kahneman, D. (1981). The Framing of Decisions and the Psychology of Choice. Science, 211, 453-458.

Key Words: Rational choice theory, framing of problems, formulation of choices, choice preferences, individual perceptions of risk, analytical methods, decision makers' attitudes toward risk, all planning areas.

This study examines the variables underlying decision making problems such as the notions of rationality, consistency and coherence. The authors specifically investigate the effects of variations in the framing of problems on the preferences and choices made by decision makers. With widely held assumptions about human rationality and the theory of rational choice at stake, the authors examine the dependence of preferences on the formulation of decision problems.

The study design consisted of a survey of students from two universities in which brief questionnaires containing hypothetical problems were used to test the effects of variations in framing on people's choices. In one problem, students were presented with a hypothetical plague during which it was estimated that 600 United States citizens would die. Two proposed programs to combat the disease were also presented to the students, each with its own distinct capacity for curbing the effects of the plague. One group of students received information regarding the success of the two programs in terms of the number of people lost under each. A second group of students received information as to the number of people expected to be saved under each program. The students were then asked to choose between programs. In

either case, the number who lived or died under each program remained the same yet the choice of programs differed, reflecting only the frame in which it was viewed (people saved versus people lost).

Through this and several similar demonstrations, the authors concluded that the psychological foundations of the perception of decision problems and their outcomes did indeed produce predictable shifts of preference when the same problem was framed in different ways. Such shifts of preference were found to occur primarily in situations where the loss of human lives or choices about money were at stake, but were neither limited to hypothetical questions nor eliminated by monetary incentives. For planners, therefore, this study may be of particular interest since framing effects can potentially play an immense role in the perception/acceptance of the risk messages they send. Since the same problem can be framed in different ways, and different frames can lead to different decisions, planners should make every attempt possible to consider the effects of framing when analyzing risks and risk perception.

112

Truitt, C.L., Clansner, J.E., & McLellan, T.N. (1989). Considerations for capping subaqueous dredged material deposits. Journal of Waterway, Port, Costal, and Ocean Engineering, 115 (6), 741-759.

Keywords: Dredge disposal, subaqueous capping.

This article examines eleven completed subaqueous capping projects and offers a summary of planning-level design and monitoring considerations. Subaqueous capping is a controlled, accurate placement of contaminated dredged material at a disposal site, which is then covered by a cap of clean isolating material. Considerations for capping site selection, cap design concepts, placement equipment and techniques, and monitoring are discussed.

Capping site selection should be based on five considerations: 1) bathymetry (bottom contours); 2) currents (both velocity and structure); 3) average water depths; 4) salinity/temperature (density) stratifications; and 5) operational requirements (such as location, distance, and surface sea state). Siting should also be planned to reduce the number of contaminant migration pathways to the environment and promote the long-term stability of the deposited material.

The capping layer must function as an adequate isolating seal. The layer must remain unbroken and resist resuspension and transport by bottom stresses at the site. Provision of an increased thickness of cap material during initial construction may be necessary to ensure that an effective cap thickness is provided for the design life of the disposal area.

Two objectives for the placement of both cap and underlying dredge material are control and accuracy. Conventional equipment can be used to release dredged and cover material from the surface. If the dredged material contains contaminants, it may be necessary to isolate the material during a portion of its decent. Submerged discharge may be accomplished using a

submerged diffuser, gravity-fed downpipe, or by using the pumpdown capability of a hopper dredge.

The capping site must be actively monitored to ensure that the cap is functioning as designed. A risk analysis should be conducted prior to construction to identify any potential problems, calculate their possible impacts, and outline solutions for each problem. A tiered monitoring program can be developed using risk analysis to evaluate critical physical, chemical, and biological factors. A tiered approach consists of: 1) defining potentially adverse effects or conditions; 2) determining the proper methods and techniques for monitoring these effects; and 3) defining various thresholds or trigger levels that will initiate more intensive monitoring and/or some remedial action.

113

Turner, R. H., & Kiecolt, K. J. (1984). Responses to uncertainty and risk: Mexican American,Black, and Anglo beliefs about the manageability of the future. Social Science Quarterly, 65, 665-679.

Key Words: Public perceptions of risk, all planning areas, all planning steps.

This article presents the results of a study which examined risk perception differences among Anglos, Blacks, and Mexican Americans. These groups were questioned about earthquake preparedness in three different subject areas: 1) attitudes toward fatalism; 2) attitudes toward science in contrast to religion or magic; and 3) attitudes toward events that may occur in the future.

The data for this study was obtained from another larger study concerned with a community-wide response to the possibility of a disastrous earthquake in Southern California. A series of face-to-face interviews were conducted with 1,450 residents of Los Angeles County. The interviews occurred between January and March 1977. Blacks were "oversampled" to ascertain adequate numbers in the final sample. The final sample included interviews from 188 Mexican Americans, 291 Blacks, and 960 Anglos, for a total sample of 1,439. An analysis of variance, followed by an analysis of covariance, were performed to determine differences which may be attributable to ethnic subculture, after controlling for four "life situation variables" including: 1) education; 2) household income; 3) occupational status; and 4) age.

Concerning the attitudes of the Anglos, Blacks and Mexican Americans toward fatalism, the findings indicate that Blacks were the most fatalistic. Anglos were second most fatalistic. Controlling for age and stratification, Mexican Americans were less fatalistic than Anglos. Substantially more Mexican Americans than Anglos or Blacks believed that an individual can take effective actions in preparation for an earthquake. The difference between Blacks and Mexican Americans is statistically significant at the .01 level for all five questions related to this point, and the difference between Anglos and Mexican Americans is statistically significant at the .01 level for two of the related questions. This finding is contrary to the results of previous studies, where Anglos were found to be the least fatalistic. This difference may be attributed

a new cultural belief of today's Mexican Americans; they believe they can influence personal outcomes in their life situations. Another factor may be the increased urbanization of Mexican Americans which has provided them with more social opportunities and a an improved quality of life.

Anglos were more receptive of science than either Blacks or Mexican Americans. This difference held even after age and stratification were controlled. Rather than directly asking about the respondents' favorability to science, the interviewers asked questions concerning earthquakes in order to determine the level of compatibility between the respondents and the scientists' frame of reference. For example, respondents were asked: 1) to explain why earthquakes occur; 2) to discuss their confidence in the ability of science to predict earthquakes; and 3) their belief in nonscientific methods of earthquake prediction.

Anglos are the most optimistic about controlling future events or (Anglo/Black and Anglo/Mexican American differences are significant at the .01 level) and Mexican Americans were more optimistic than Blacks. One reason may be that Mexican Americans face less discrimination in the job market than Blacks, and their "life situation" is better. The two groups have approximately the same income, but Mexican Americans have considerably less education and occupational social status.

114

U.S. Army Corps of Engineers (1988). Draft report: Evaluation of risk and uncertainty analysis in Corps civil works planning. (Contract DACW72-86-D-0012, Task Order 0003). The Greeley-Polhemus Group, Inc. West Chester, PA

Key Words: Navigation, flood control, all planning steps, analytical methods.

The purpose of this report is to provide preliminary findings on the effectiveness of the methods used by the U. S. Army Corps of Engineers (COE) to address issues of risk and uncertainty in planning for navigation and flood control. Twenty project feasibility planning studies which exemplify current practices for treating risk and uncertainty, were evaluated in the development of this report. The study's framework for analysis was adopted from the *Principles and Guidelines* and the COE six-step planning process. This report has been developed in anticipation that it will lead to improved methods for evaluating uncertainty in COE planning since no clear policy currently exists.

The broad findings indicate that risk and uncertainty analyses are:

1) Generally recognized as fundamental requirements in plan preparation and were developed in every report reviewed.

2) Handled both explicitly and implicitly in planning reports, but lack a specific rationale regarding the role of risk.

3) Internalized into the planning process; therefore the planner assumes the role of decision maker by ignoring or withholding information and presenting the plan as risk free.

4) Inconsistently analyzed and displayed.

5) Frequently unnecessarily limit and under utilize existing data that could be used in assessing risk and uncertainty.

6) Handled as discrete, separable concerns from step-to-step and the possible cumulative effects of uncertainty are not carried through the evaluation of alternatives and selection process.

The six steps of the COE planning process are: 1) specification of problems and opportunities; 2) inventory and forecast; 3) formulation of alternative plans; 4) evaluation; 5) comparison of alternatives; and 6) plan selection. The following findings as related to each of the six steps, were indicated in most of the studies.

Step 1: Included an extensive public involvement program targeted to the general public, but did not clearly identify the alternative preferred by the public and did not use statistically valid risk analysis methods.

Step 2: Lacked adequate documentation of the accuracy and uncertainty of the without project condition.

Step 3: Provided detailed descriptions of the formulation process of the alternatives and clearly described the screening processes used to determine which alternatives to examine in greater detail.

Step 4: Performed a comprehensive benefit/cost analysis, but little analysis of risk and uncertainty was documented and benefit/cost ratios were presented as if they were certain.

Step 5: Failed to effectively document and display significant areas of risk and uncertainty and provide a range of possible impacts on the process used to select the final recommended plan.

Step 6: Failed to display and communicate significant sources of professional judgement and the degree potential error could impact benefits and costs.

The planner is responsible for the identification, quantification and evaluation of risk and uncertainty; therefore, planners should be required to clearly display how assumptions and decisions concerning key parameters influence selection of the final plan. This report proposes the development of "a rigorous analysis framework and guidance" enabling the decision maker to consider tradeoffs of uncertainty with other considerations in the judgement process.

115

U.S. Army Corps of Engineers, Water Resources Support Center (1990). Guidelines for risk and uncertainty analysis in water resources planning : Principles with technical appendices Vol. I, Fort Belvoir, VA: Institute for Water Resources.

Key words: Water supply planning, risk and uncertainty analysis, expected risk, risk communication and display, analytical methods.

This report provides a basis for a useable procedure for more explicit treatment of uncertainty and risk within the Corps Civil Works Planning framework. The guidelines presented are directive rather than prescriptive in intent, and are therefore instructive in purpose. Details on accepted mathematical and probabilistic techniques are included, as well as a discussion of risk and uncertainty management techniques. A primary focus of the report is to offer objectives and strategies for communicating and displaying the concept of risk to those external to the Corps operating procedures. The generic approach of the study offers a viable starting point for Corps planners.

To the planner, the concept(s) of risk and uncertainty must be stated explicitly and technically. In mathematical terms expected risk may be precisely defined as:

$$\int_0^{\infty}\int_{-\infty}^{\infty} x(t)\,P(x(t))\,dxdt$$

where x(t) denotes risk as a function of time, and P(x(t)) denotes the probability density function that represents risk. Risk and uncertainty can also be represented conceptually as a continuum of knowledge. Along the road from complete ignorance to complete certainty, one necessarily encounters uncertainty. As more knowledge is gained, subjective probabilities (risks) arise and become associated with different events.

The author points out that there are other important elements to dealing with risk and uncertainty than those identified in the Planning and Guidelines. Specifically, a planner must account for the decision makers' and public's attitudes toward risk, explicitly present assumptions of risk analyses and some justification for their use, identify all key variables and planning objectives, and finally, use creative display techniques to help analyze and communicate the findings in an understandable way. To simply communicate risk through technical appendices is not desirable to the general public who are moved more by the qualitative aspects of risk. In characterizing how the Corps position concerning risk differs from the formulation of the public, the author stresses that "...Balancing benefits, costs, residual damages, and the like is just so much bureaucratic esoterica to the public. They want safety and could care less about the NED objective."

The report concludes with a work plan providing a generic approach to the identification, assessment, and display of risk and uncertainty in a typical Corps project. The guideline is based on the conceptual framework of the Planning and Guidelines and is meant to be modified and improved to fit the unique requirements of specific projects.

116

U.S. Army Corps of Engineers, Water Resources Support Center (1990). Guidelines for risk and uncertainty in water resources planning: Example cases, Navigation, Vol. II, [Draft report]. Fort Belvoir, VA: Institute for Water Resources.

Key Words: Navigation, risk analysis, all planning steps, analytical methods.

The purpose of this report is to present a hypothetical navigation case study which illustrates and supports the principles and selected techniques outlined in the Guidelines and Procedures for Risk and Uncertainty in Corps Civil Works Planning. The hypothetical study occurs in Star City located on a large inland Bay on the coast. Real data is used whenever possible in order to represent realistic situations. The study proceeds through the six planning steps and risk and uncertainty issues are confronted during each step. Advanced theoretical and statistical methods are not relied upon; the report is "user friendly." The case study indicates that the results of risk and uncertainty analyses can be used constructively in the plan formulation process, and can be reasonably argued as a justification for deviating from the NED plan.

Star City is served by an existing navigation project designed for vessels up to 40,000 deadweight tons (DWT). Currently, vessels up to 80,000 DWT routinely navigate the channel. This study examines the need and advisability of improving the Star City navigation project.

The need and advisability of improvement of the Star City project was determined by combining risk and uncertainty analysis with each the six planning steps which include: 1) specification of problems and opportunities; 2) inventory and forecast; 3) evaluation; 4) detailed evaluations; 5) detailed analysis; and 6) plan selection. The four critical elements of risk and uncertainty analysis which were integrated into the six planning steps are: 1) problem identification; 2) understanding of public views; 3) understanding public attitudes about risk and uncertainty; and 4) establishing specific risk and uncertainty planning objectives.

It is important that decision-makers not regard project effects as known and certain events. When possible, navigation project analysis should identify the marginal risks associated with the marginal benefits of any decision. Straightforward admittance of limited knowledge is much better than the traditional presentation of a single variable. The analyst may use confidence intervals, tables, and graphs to stress the uncertain nature of project effects, but still show best estimates.

In the case presented, if risk and uncertainty analysis had not been performed, the tradeoff would simply be that wider channels inflicted additional cost to net benefits. Considering the risk analysis, analysts could assert that selection of a wider channel still involves a probability of obtaining NED-magnitude benefits, but it may be lessened by wider channels. In this way decision makers can use results from risk and uncertainty analysis as a justification for deviation of the NED plan.

117

Van Der Plight, J., & Midden, C. (1990). Chernobyl: Four years later: Attitudes, risk management and communications. Journal of Environmental Psychology, 10(2), 91-99.

Key Words: Public perceptions of risk, difference in public attitudes regarding risk of natural and man-made hazards, public behavior under risk.

This literature review covers many of the psychological effects of the accidents at Chernobyl and Three Mile Island. Presented are four points: 1) risk perception; 2) decisions and coping with uncertainty; 3) public attitudes; and 4) risk management and communication. This article sites research from throughout Europe and the United States. Especially cited is a Swedish study following the Chernobyl accident by Drottz & Sjoberg (1990)*.

The cited literature found that the public perception of a possible nuclear accident results in "hypervigilance" along with a belief that a satisfactory solution can be found. This condition results in an indiscriminate openness to all information, which in turn results in the public becoming overwhelmed with information and reaching a decisional stalemate. These forms of decisional stress are cited from works by Janis and Mann (1977)**.

This article is very insightful for gaining an understanding into the publics' reactions and resulting stresses towards contemplation or the realization of dealing with a catastrophe.

* Drottz, B., & Sjoberg, L. (1990). Risk perception and worries after the Chernobyl accident. Journal of Environmental Psychology, 10, 135-149.

** Janis, I., & Mann, L. (1977). Decision making. New York: Free Press.

118

Van Haveren, B. (1986). Management of instream flows through runoff detention and retention. Water Resources Bulletin, 22(3), 399-404.

Key Words: Flood control, structural and nonstructural, instream flows, hydrograph modification.

This paper is a literature review of stream management methods including retention and detention structures and land treatments, for soil and water conservation. Design concepts for run-off control structures are discussed in relation to instream flow management objectives.

Surface runoff control for hydrograph modification research is cited including: in channel detention or retention of flows, and increase in depression storage, increase in infiltration capacity. Hydrologic simulation is offered as a potential tool for project design and feasibility analysis and applicable research is cited.

The author did not uncover any literature where the project objective was to manage the hydrograph or flow duration curve for specific instream flow purposes. However, conceptually it is plausible that a mix of runoff detention and retention treatments could be applied to a small basin to accomplish predetermined hydrograph modification objectives.

119

Van Rijn, L. C. (1986). Sedimentation of dredged channels by currents and waves. Journal of Waterway, Port, Coastal and Coastal Engineering, 112(5), 541-559.

Key Words: Dredging, mathematical model for sedimentation of dredged channels, all planning steps, analytical methods.

The purpose of this article is to present a two-dimensional vertical mathematical model for sedimentation of dredged channels. This model is based on all relevant transport processes (i.e., convection, mixing and settling) rather than the strong schematization of the transport processes, on which traditional models are based. A sensitivity analysis demonstrates the influence of the current refraction effect and the wave shoaling effect on the sedimentation process. Finally, two applications of the mathematical model are presented.

A mathematical model for suspended sediment transport by current and waves is proposed. Not considering the transport by longitudinal mixing and assuming steady state conditions, the convection-diffusion equation for the wave period-averaged variables can be expressed as:

$$\frac{a}{ax}(buc) + \frac{a}{az}\left[b(w - w_s)c\right] - \left(\frac{a}{az}\, be_{s,cw}\, \frac{ac}{az}\right) = 0$$

where

u = longitudinal velocity at height z above the bed;
c = sediment concentration;
w_s = particle fall velocity of suspended sediment;
$e_{s,cw}$ = sediment mixing coefficient by current and waves;
b = flow width;
x = longitudinal coordinate; and
z = vertical coordinate.

The sensitivity analysis identified the influence of controlling parameters on the estimated rate of sedimentation. The major controlling parameters were: 1) the current; 2) wave and sediment transport conditions at the inlet ($x = 0$); 3) the particle fall velocity of the suspended sediment; and 4) the direction of the approaching current in relation to the streamline refraction effect and the wave height variations across the channel. The author found that the application of a mathematical model is only meaningful when detailed and accurate information of the

boundary conditions is available. Otherwise, simple sedimentation graphs should be utilized to obtain rough estimates of the sedimentation rates.

Two examples of application are presented including a flume experiment and a field experiment. The results of the flume experiment indicated that the computed suspended load transport is too large in comparison with 'measured' values. These measured values were computed from the measure velocity and concentration profiles. The computed sedimentation and erosion rates were also too large in comparison with the measured values. In the field experiment, the agreement between measured and computed bed level profiles in the middle of the channel where a siltation height of about 1.5 m could be observed, was fairly good. The maximum deviation between measure and computed values in the middle section was 0.3 m.

The author concludes that: 1) comparison of measured and computed sediment concentration profiles and bed level changes shows reasonable agreement; 2) a current approaching an oblique channel is refracted resulting in contraction of the streamlines; and 3) waves propagating in a dredged channel are reduced in height due to the increased water depth and the influence of the wave height reduction on the sedimentation process is relatively small. As a result, it seems acceptable to apply a constant wave height outside and inside the channel.

120

Vick, S. G., Atkinson, G. M., & Wilmot, C. I. (1985). Risk analysis for seismic design of tailings dams. Journal of Geotechnical Engineering, 111(7), 916-933.

Key Words: Dam safety, probabilistic seismic risk analysis, all planning steps.

This article discusses the importance of seismic risk analysis for tailings dams. The authors present a case study of the design of a tailings dam in central Nevada to illustrate seismic risk analysis and its use in developing seismic design parameters. Acceptable levels of lifetime failure probabilities are addressed.

Consequences from tailings dam failures can be divided into three categories: monetary costs, environmental costs, and loss of life. Partially due to the difficulty of assigning a monetary cost to loss of life, risk analysis techniques for water retention and dam design have been accepted slowly. If loss of life appears significant as a consequence of failure, decision makers tend to avoid equating this loss with monetary loss. In such a case, *deterministic* techniques which refer to the "largest events reasonably possible or reasonably expected," are commonly used to determine parameters for seismic failure. The authors suggest that formal risk analysis may be most appropriate in situations involving remote areas and moderate levels of seismicity, where the proper design solution may not be readily determined upon the basis of engineering judgement.

Probability risk analysis addresses two issues: 1) the probability of occurrence of a given loading condition; and 2) evaluating the consequences if that loading is exceeded. The product of these two variables is the risk-cost which may be added to construction cost of the option.

In this way, probabilistic seismic risk analysis offers decision makers a method for achieving an optimal balance between risk and cost.

Design for the Nevada Moly tailings dam began by defining four separate design options. Each option was assigned a design seismic acceleration, a_d, which was conservatively estimated based on judgement, empirical data, and preliminary dynamic analysis. Then, construction costs and costs due to seismic failure were estimated based on cost of tailings cleanup, restoration of the disturbed area, dam repair, and mill shut down during the repair period. Since the nearest downstream habitation is 15 miles away, loss of human life was not factored into the risk-cost evaluation. Results of the cost estimations showed that designing for short-recurrence events has a high total cost dominated by the expected cost of failure. High total costs were also found with long-recurring events because of very high initial investments in failure resistance.

The case presented in this article, as well as accepted parameters for similar projects, suggest that "a lifetime probability failure of a few percent may be acceptable for many tailings dams in remote areas." However, in situations where seismic risk does not prove to be the dominant factor in tailings dams failure potential, consideration of other failure factors such as overtopping, piping, and static slope instability are vital in development of the lifetime failure probabilities.

121

Vlek, C., & Stallen, P. (1980). Rational and personal aspects of risk. Acta Psychologica, 45, 273-300.

Key Words: Public and individual perceptions of risk, public behavior under risk, all planning areas, all planning steps.

This article develops a 'psychological categorization' and rational ordering of the numerous aspects of risk. It focuses on: 1) definitions of risk; 2) various possible human reactions to risky situations; and 3) fundamental aspects of risky decisions.

Risk may be defined qualitatively as: 'the complete description of possible undesired consequences of a course of action, together with an indication of their likelihood and seriousness.' Risk can also be quantitatively defined as: 1) the probability of loss; 2) the size of (credible) loss; 3) expected loss; 4) the variance of the probability distribution; 5) a semi-variance of the utility distribution; and 6) a linear function of the expected value and the variance.

Personally experienced risk may be delineated by: 1) physiological measurements such as heart rate; 2) behavioral measurements like revealed preferences; and 3) 'cognitive' measurements such as verbal descriptions, opinions and expressed preferences. The degree of caution exercised during a risky activity is directly related to the perceived risk of the activity. There are four critical questions in emergency decision situations:

1) Are the risks serious if I don't take protective action? If the answer is no, the risks are acceptable. If yes, one goes to the next question.

2) Are the risks serious if I take the most available protective action? If not, one may select the safer option with acceptable risk. If yes, one goes to the next question.

3) Is it realistic to hope to find an acceptable solution? If not, there is no acceptable risk and one goes into a state of 'defensive avoidance' and then may justify a too risky option, attempt to gain time, or displace responsibilities. If yes, one asks the next question.

4) Is there sufficient time to search for and evaluate an acceptable alternative? If not, one goes into a state of 'hypervigilance' with respect to signs of danger and possibilities for escape characterized by impulsive choices. If yes, one remains in a 'normal state of vigilance' and thoroughly searches for an acceptable option.

Fundamental characteristics of risky decisions include: 1) voluntariness of exposure; 2) controllability of consequences; 3) distribution of consequences in time; 4) distribution of consequences in (social-)geographical space; 5) context of an individual's probability assessment; 6) context of an individual's accident evaluation; and 7) combinations/interactions of accident probability and seriousness. In determining acceptable risk, an optimal and somewhat constant level of risk is sought, resulting in a balance between perceived benefits and risks.

122

Von Wintrfeldt, A., John, R., & Borcherding, K. (1981). Cognitive components of risk ratings. Risk Analysis, 1(4), 277-287.

Key Words: Public perceptions of risk.

This article examines what lay people mean when they judge the risk of activities that involve the potential for accidental fatalities. The authors also compare the responses from the U.S. to Germany.

The authors implemented a survey on American and German students, having them rate the "overall risk" of 14 "dangerous" activities and provide 3 fatality estimates: the number of fatalities in an average year, the individual yearly fatality probability , and the number of fatalities in a "disastrous accident."

In response to the authors questionnaire they found three main results: 1) Technical fatality estimates were in accordance with estimates from professional technicians; 2) Individual fatality probability emerged as the best predictor of intuitive risk ratings; 3) Disaster estimates were negatively correlated with risk ratings. When responses were compared between American and German respondents, it was found that German students gave higher disaster estimates for

some large scale technologies. From variance in the order of the questions, it was found that actively thinking about fatality estimates appeared to shape risk ratings in the direction of a closer relationship with fatality probability.

The authors found that the students' technical estimates were not grossly different from professional estimates, although they were consistently underestimated for large numbers and overestimated for small numbers.

123

Waterstone, M. (1989). Risk analysis and management of natural and technological hazards: A social/behavioral science perspective. In Y. Y. Haimes & E. Z. Stakhiv (Eds.), Risk Analysis and Management of Natural and Man-Made Hazards (pp. 72-80). New York: American Society of Engineers.

Key Words: Decision makers' attitudes toward risk, public perceptions of risk, risk communication, all planning areas, all planning steps, analytical methods.

The author discusses the process of risk analysis in three phases, then proposes that the roles of scientists and public officials should be clearly defined and separate for proper risk analysis. Other aspects of risk, such as risk communication, informed consent, rationality, context of risk and risk assessment, are also addressed.

The first phase of the risk analysis process includes: 1) studying the nature of a hazard; 2) estimating probability of occurrence; and 3) estimation of potential damage. This phase is best implemented by scientists and specially trained experts. The second phase involves the determination of "acceptable risk," or the amount of risk which society would deem acceptable. The author argues that scientists are not more qualified to make decisions in the second phase than policy makers or the general public. Although scientists may be better informed regarding potential consequences, they do not have a more preferred or legitimate claim than anyone else in determining alternatives. The third phase involves evaluations of risk/benefit tradeoffs. This phase requires interaction between scientists and public officials. Risk management, the final phase of the process, requires extensive involvement of the scientists and policy makers. Clearly defined roles of scientists and public officials would prevent: 1) scientists from making value judgements of "how safe is safe;" and 2) public officials from making technical judgements which they are not adequately skilled to make.

Scientists and engineers tend to perceive risk in a much narrower perspective than social/behavioral scientists, public policy makers and public officials. These differing perspectives cause differing expectations in the risk analysis/management process, which may lead to conflict. To resolve this problem, the author proposes clearly distinct roles for scientists and public officials in the risk analysis/management process.

Werner, D. (1985). Psycho-social stress and the construction of a flood-control dam in Santa Catarina, Brazil. Human Organization, 44(2), 161-167.

Key Words: Dams, flood control, decision makers' attitudes toward risk, public's exhibited behavior under risk, public perceptions of risk, social impact assessment, Brazil.

A survey of relocated farmers and Indians examines some of the "hidden" affects which resulted from the construction of a flood-control dam on the upper Itajai River of Santa Catarina, Brazil. This study reveals stress, stress-related illness, and particular aspects of the project which caused increased problems for the Indians and farmers who resided in the area.

The survey was based on a random sample of 65 adults that lived in the township where the dam was built. The farmers and Indians were asked questions concerning losses related to the dam, indemnities paid, stress, health, and sociodemographic information such as age and sex.

The author cites findings from previous studies that depict stressful aspects of dam construction. Some of the affects include: 1) physical suffering, if some people experience water shortages after a forced resettlement; 2) increases in crime, violence, or alcoholism due to the influx of workers; 3) diseases resulting from the reservoir itself such as river blindness, schistosomiasis, or trypanosomiasis; and 4) psychological problems associated with an uncertain future related to resettlement. Furthermore, previous studies indicate that persons experiencing stress, such as the loss of a spouse, relocation, or the loss of a job, may be more susceptible to physical ailments such as rheumatism or angina pectoris.

Different variables were correlated with psychosomatic stress. It was found that experiencing a loss due to the dam's construction did not predict stress among the Indians or the farmers. While not statistically significant, survey findings did indicate that people who experienced more uncertainty demonstrated higher levels of stress. For example, those who had not received their indemnity exhibited more stress than those who had received it. According to the author, women generally demonstrated more psychosomatic stress than men, which may have been due to their lack of contact with outside public agencies.

The mean amounts of stress experienced by the Ibirama farmers and Indians were compared against 12 other ethnic groups. These 12 groups were surveyed by John Berry using the same psychosomatic stress scale used in this study. Out of 20 items, the Ibirama farmers' indicated they were under stress on a mean of 9.13 factors, and the Indians' mean was 8.12. In comparison, the means of the 12 groups ranged from 1.79 for Canadian farmers to 7.03 for the Cree Indians. The differences between the Ibirama people and the 12 groups were statistically significant, with the exception of the Cree Indians who had also experienced the construction of a dam in their territory. Furthermore, the author found statistically significant ($P < .01$) correlations between social stress and leadership dissatisfaction. This leadership crisis may be attributed to the need for negotiations with large business or government agencies.

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West, M. W. (1988). Dams and earthquakes: A shaky relationship. Civil Engineering, 58(4), 64-67.

Key Words: Dam safety, earthquakes, risk assessment, all planning steps, analytical methods.

This article presents a "phased approach" for analyzing the effects of seismic activity on dams and supports this method with a case study. The study investigates two projects located in one region. The first project is the proposed enlargement of Sulphur Creek Reservoir, and the second project involves the construction of a new dam on the West Fork of the Bear River, southeast of Evanston, Wyoming.

A deterministic assessment approach has been utilized in the past, but this method possesses drawbacks including: 1) inadequate knowledge of seismogenesis and recurrence intervals; 2) difficulties in evaluating geological and seismological evidence for earthquake hazards; and 3) problems applying evaluation results to a particular site. A phased geologic assessment could minimize these problems and demonstrate variance among projects in the amount of study required. The phased approach involves:

Phase I - Development of the current geological and seismological data base by reviewing federal earthquake catalogs for signs of hazard. In the case where no evidence is discovered, design earthquakes can be estimated through probabilistic methods.

Phase II - Aerial photos or field examinations may be performed in an effort to answer questions which still remain after completion of Phase I.

Phase III- Studies in this phase are necessary when the presence of a significant earthquake hazard is present. Several investigative techniques such as, geologic mapping, geophysical exploration and trenching of suspected seismogenic faults are pursued in this phase.

Two projects illustrating the phased approach are presented. The first project presented involved the proposed enlargement of the Sulphur Creek Reservoir southeast of Evanston Wyoming. The second project involved the construction of a new dam on the West Fork of the Bear River south of Evanston in north-central Utah. After the U.S. Geological Survey presented evidence of fault scarps (scarps are normally associated with large magnitude earthquakes) Phase II activities (aerial photos), were executed. The photos suggested evidence of a potential hazard to dam safety existed. Phase III studies involving an exploratory trenching program ensued. The findings indicated that two major faulting events have occurred in the history of the region. Considering the recurrence intervals, the next event could occur tomorrow or several hundred years hence. Vertical surface displacements of one to five meters could occur along the Bear River fault, but none of these faults intersected a dam foundation in the study area. Tectonic fault displacement in the foundations of the three dam sites under consideration did not prove to be a safety or design issue.

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Whipple, C.G. (1986). Dealing with uncertainty about risk in risk management. In National Academy of Engineering, Hazards: Technology and Fairness (pp. 44-59). Washington DC: National Academy Press.

Key Words: Decision makers' attitude toward risk, public perception of risk, conservative analytic method of assessing risk, the *de minimis* approach to regulation of risk, all planning areas, all planning steps, analytical methods.

This article discusses the use of conservative analytic approaches in risk decision making. Upon analysis, the author recommends the use of an approach which would categorize small uncertain risks as *de minimis*.

Through the conservative analytic approach assumptions are systematically selected, resulting in estimates of high risk. Use of conservative analytic assumptions essentially avoids the issue of proper risk management and can lead to the exaggeration of risks. This could result in increased costs, misallocation of scarce resources, and a false sense of security.

The *de minimis* risk approach has many benefits such as: 1) simplifying the regulatory process by providing an alternative to setting standards for substances that pose the lowest risks; 2) industry support since it defines a threshold for regulatory involvement and provides a risk target for avoiding regulation; and 3) reduce pressure on regulatory agencies to produce scientific judgements about low level risks where information is limited or unavailable. Drawbacks include: 1) qualitative public reaction to de-regulating quantitatively low risk substances; and 2) the possibility of multiple *de minimis* exposures resulting in large aggregate risk.

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White, Gilbert F. (1964). Choice of Adjustment to Floods, Department of Geography Research Paper #93, Chicago: University of Chicago Press.

Key Words: Flood control, alternative adjustments to flood hazards, public and individual perceptions of risk, decision makers' attitudes toward risk.

This paper examines the conditions surrounding flood plain managers' choices among alternative adjustments to floods. Through an ardent study of several flood plain establishments, the author refutes the commonly held notion that the decision either to protect or not to protect is the only choice open to managers of flood plain property. As such, he investigates several alternative adjustments to flood hazards, and suggests the foundations for their selection.

Several factors were found to affect the paths which adjustments take from the first use of flood plain land, including:

- the perception of the flood hazard
- the perception of the possible adjustments
- the technical feasibility of particular adjustments
- the economic efficiency of these choices
- the timing and incidence of decisions by private and public managers

The technical feasibility of adjustments was found to differ relative to the frequency, stage, duration, and velocity of flooding, while their economic efficiency varied according to the type of flood plain establishments present, and assumptions as to interests rates and flood frequencies.

Choices among flood plain managers were found to reflect both their location in the flood plain within reach of the latest major flood, and their length of tenure in the flood plain. Alternatives preferred to loss bearing generally showed net benefits at lower interest rates and higher assumed flood frequencies. Decisions among private managers were also guided to a considerable degree by public attitudes and actions regarding alternatives. Such attitudes and actions, the author suggests, could be strengthened by local communities by promoting:

- basic hydrologic and hydraulic studies
- dissemination of resulting data
- flood forecasting and warning services
- regulation of channel encroachment
- knowledge of techniques of alternative adjustments
- regulation of land use
- acquisition of suitable land

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Wilhite, D. A., & Wood, D. A. (1985). Planning for drought: The role of state government. Water Resources Bulletin, 21, 31-38.

Key Words: Drought, emergency water supply planning, all planning steps.

This paper focuses entirely on drought emergency water planning and presents the results of a 1982 survey of all states to determine the status of drought planning.

Of the states surveyed, at least 37 were reported as not having initiated drought-planning efforts, although drought frequencies, as represented by the Palmer Index, are shown to have extreme values of 4.0 in many of these states as much as 10 percent of the time (period 1931-1978). A review of selected state drought plans for Colorado, South Dakota, and New York is given. The plans are shown to differ based on each state's unique water supply and management problems and the consequent impacts of drought emergency plan implementation. In each of the three states, an organizational structure has been created to coordinate the assessment and response activities of state and federal agencies.

The article effectively illustrates the potential of formal water resources planning for alleviating the impacts of water shortage. The presence of a drought emergency plan may facilitate the structure of an all-encompassing water emergency plan, provided that the incentive and support to do so can be generated by local state or federal initiatives.

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Wynne, B. (1983). Redefining the issues of risk and public acceptance: The social viability of technology. Futures, 15, 13-32.

Key Words: Public perception of risk, decision makers' attitude toward risk, all planning areas, all planning steps.

Technology has progressed in such a manner that it has become isolated from the social arena in which technology is to be used. As a result, the viability of technology is undermined and becomes more susceptible to public resistance. A conceptual framework is proposed which enlarges the notion of risk as normally used in risk assessment. This is done by the inclusion of social issues into risk assessments and policies concerning technology.

Most technical experts, policy analysts, and decision makers perceive technology simply as "a physical entity" with separate risks which can be controlled with further action (and added cost) if necessary. Non-technical issues are not pertinent to the expert; they are commonly regarded as spurious and irrational. In contrast, the social view of technology held by the public is developed through ordinary interaction with technology.

Technical experts generally maintain the attitude that technological progress is hindered by public resistance. If social resistance to new technologies disappeared, the projects would progress and operate just as the technical experts predicted. The author asserts that technical experts blame public resistance for inefficiencies which are actually internal to the development of the technology. These inefficiencies could be resolved by involving the public at the innovation and commitment stages of a project, not after commitments have been made and time is limited for the integration of public views.

APPENDIX A

CROSS-REFERENCE TABLES

Annotations for Planning Areas

Water Supply Planning Emphasizing Drought	2, 10, 20, 21, 23, 33, 36, 37, 47, 52, 56, 64, 69, 70, 72, 73, 77, 78, 79, 91, 111, 115, 128
Emergency Water Planning Earthquake & Toxic Spills	13, 19, 20, 21, 23, 33, 38, 39, 42, 47, 48, 52, 56, 59, 64, 68, 73, 75, 78, 83, 86, 88, 111, 125, 128
Flood Control Structural and Non-Structural	1, 17, 18, 19, 20, 23, 33, 47, 49, 52, 53, 56, 59, 64, 71, 73, 78, 86, 95, 107, 110, 111, 114, 118, 124, 127
Dam Safety	4, 8, 12, 19, 20, 23, 33, 47, 52, 56, 64, 73, 78, 80, 81, 107, 111, 120, 124, 125
Navigation	20, 23, 33, 43, 45, 47, 52, 56, 58, 64, 73, 78, 108, 111, 114, 116
Coastal Zone Protection	20, 22, 23, 33, 45, 47, 52, 56, 64, 73, 74, 78, 94, 111
Dredging and Dredge Disposal	20, 23, 30, 31, 33, 41, 47, 52, 56, 63, 64, 65, 66, 73, 78, 96, 105, 111, 112, 119
Natural Ecosystem Problems	20, 22, 23, 33, 40, 43, 47, 52, 56, 61, 64, 73, 78, 105, 111

Annotations for Risk Perspectives and Analytical Methods

Public and Individual Perceptions of Risk	5, 6, 7, 9, 11, 15, 20, 23, 25, 26, 29, 32, 33, 34, 44, 46, 47, 49, 50, 52, 53, 54, 55, 56, 60, 62, 64, 65, 73, 78, 82, 84, 85, 89, 90, 92, 93, 95, 97, 98, 99, 101, 102, 103, 104, 105, 109, 110, 111, 113, 117, 121, 122, 123, 124, 126, 127, 129
Difference In Public Attitudes Toward Natural and Man-Made Hazards	29, 32, 49, 60, 82, 81, 92, 102, 103, 104, 105, 106, 117
Public Behavior Under Risk	5, 6, 9, 25, 28, 32, 33, 38, 47, 50, 51, 52, 53, 56, 60, 64, 71, 76, 77, 78, 88, 89, 90, 92, 93, 95, 97, 102, 105, 109, 110, 117, 121, 124
Decision Makers' Attitudes Toward Risk	3, 11, 14, 15, 17, 18, 19, 20, 23, 24, 25, 26, 29, 35, 36, 40, 44, 50, 54, 56, 57, 58, 64, 67, 73, 76, 85, 88, 92, 100, 101, 102, 104, 109, 111, 123, 124, 126, 127, 129
Analytical Methods	4, 10, 15, 20, 23, 28, 30, 31, 35, 37, 40, 41, 43, 45, 46, 52, 53, 56, 61, 65, 66, 68, 70, 72, 74, 75, 76, 77, 79, 80, 81, 87, 91, 96, 97, 100, 105, 107, 109, 111, 112, 114, 115, 116, 119, 123, 125, 126

Comprehensive Risk Matrix

	Public and Individual Perceptions of Risk	Difference in Public Attitudes Toward Risk of Natural and Man-Made Hazards	Public Behavior Under Risk	Decision Makers' Attitudes Toward Risk	Analytical Methods
Water Supply Planning Emphasizing Drought	7, 11, 14, 15, 20, 21, 23, 26, 29, 32, 33, 46, 47, 49, 52, 54, 55, 56, 60, 64, 73, 77, 78, 84, 89, 92, 93, 97, 98, 99, 101, 102, 103, 111, 113, 121, 122, 126, 129	21, 29, 32, 49, 60, 82, 89, 92, 102, 103, 106	21, 25, 28, 32, 33, 47, 51, 52, 56, 60, 64, 76, 78, 89, 92, 93, 97, 102, 121	2, 3, 11, 14, 15, 20, 21, 23, 24, 25, 26, 29, 35, 54, 56, 57, 64, 67, 73, 76, 85, 92, 100, 101, 102, 111, 123, 126, 129	10, 15, 20, 21, 23, 28, 35, 37, 46, 52, 56, 69, 70, 72, 77, 79, 87, 91, 97, 100, 111, 115, 123, 126
Emergency Water Planning, Earthquake and Toxic Spills	7, 11, 14, 15, 20, 21, 23, 26, 29, 32, 33, 38, 46, 47, 48, 49, 52, 54, 55, 56, 60, 64, 73, 78, 82, 84, 89, 92, 93, 97, 98, 99, 101, 102, 103, 111, 113, 121, 123, 126, 129,	21, 29, 32, 38, 48, 49, 60, 82, 89, 92, 102, 103, 106	21, 25, 28, 32, 33, 38, 47, 48, 51, 52, 56, 60, 64, 76, 78, 88, 89, 92, 93, 97, 102, 121	3, 11, 14, 15, 19, 20, 21, 23, 25, 26, 29, 35, 38, 48, 54, 56, 57, 64, 67, 73, 76, 78, 85, 88, 92, 100, 101, 102, 111, 123, 126, 129	15, 20, 21, 23, 28, 35, 46, 52, 56, 68, 75, 87, 97, 100, 111, 123, 125, 126
Flood Control, Structural and Non-Structural	7, 11, 14, 15, 20, 22, 23, 29, 32, 33, 44, 46, 47, 49, 52, 53, 54, 55, 56, 60, 64, 73, 78, 82, 84, 89, 92, 93, 95, 97, 98, 99, 101, 102, 103, 110, 111, 113, 121, 123, 124, 126, 127, 129	29, 32, 49, 60, 82, 89, 92, 102, 103, 106	25, 28, 32, 33, 47, 51, 52, 53, 56, 60, 64, 71, 76, 78, 89, 92, 93, 95, 97, 102, 110, 121, 124	3, 11, 14, 15, 17, 18, 19, 20, 23, 25, 26, 29, 35, 44, 54, 56, 57, 58, 64, 67, 73, 76, 85, 92, 100, 101, 102, 111, 123, 124, 126, 127, 129	15, 20, 23, 28, 35, 46, 52, 53, 56, 87, 87, 97, 100, 111, 114, 118, 123, 126
Dam Safety	7, 11, 12, 14, 15, 20, 23, 26, 29, 32, 33, 46, 47, 49, 52, 54, 55, 56, 60, 64, 73, 78, 80, 82, 84, 89, 92, 93, 97, 98, 99, 101, 102, 103, 111, 113, 121, 123, 124, 126, 129	12, 29, 32, 49, 80, 82, 89, 92, 102, 103, 106	25, 28, 32, 33, 47, 51, 52, 56, 60, 64, 76, 78, 80, 89, 92, 93, 97, 102, 121, 124	3, 4, 8, 11, 12, 14, 15, 18, 20, 23, 25, 26, 29, 35, 54, 56, 57, 64, 67, 73, 76, 80, 85, 92, 100, 101, 102, 111, 123, 124, 126, 129	4, 15, 20, 23, 28, 35, 46, 52, 56, 80, 81, 87, 97, 100, 107, 111, 120, 123, 125, 126

Comprehensive Risk Matrix (Continued)

	Public and Individual Perceptions of Risk	Difference in Public Attitudes Toward Risk of Natural and Man-Made Hazards	Public Behavior Under Risk	Decision Makers' Attitudes Toward Risk	Analytical Methods
Navigation	7, 11, 14, 15, 20, 23, 25, 29, 32, 33, 45, 46, 47, 49, 52, 54, 55, 56, 60, 64, 73, 78, 82, 84, 85, 89, 92, 93, 97, 98, 99, 101, 103, 111, 113, 121, 123, 126	29, 32, 45, 49, 60, 82, 89, 92, 103, 106	25, 28, 32, 33, 45, 47, 51, 52, 56, 60, 64, 76, 78, 89, 92, 93, 97, 121	3, 11, 14, 15, 20, 23, 25, 26, 29, 35, 45, 54, 56, 57, 64, 67, 73, 76, 85, 92, 100, 101, 111, 123, 126	15, 20, 23, 28, 35, 43, 45, 46, 52, 56, 87, 97, 100, 108, 111, 114, 115, 123, 126
Coastal Zone Protection	7, 11, 14, 15, 20, 23, 25, 29, 32, 33, 45, 46, 47, 49, 52, 54, 55, 56, 60, 64, 73, 78, 82, 84, 85, 89, 92, 93, 94, 97, 98, 99, 101, 103, 111, 113, 121, 123, 126	29, 32, 45, 49, 60, 63, 82, 89, 92, 94, 103, 106	25, 28, 32, 33, 45, 47, 51, 52, 56, 60, 64, 76, 78, 89, 92, 93, 94, 97, 121	3, 11, 14, 15, 20, 23, 25, 26, 29, 35, 45, 54, 56, 57, 64, 67, 73, 76, 85, 92, 94, 100, 101, 111, 123, 126	15, 20, 23, 28, 35, 45, 46, 52, 56, 74, 87, 97, 100, 111, 123, 126
Dredging and Dredge Disposal	7, 11, 14, 15, 20, 23, 25, 29, 32, 33, 46, 47, 49, 52, 54, 55, 56, 60, 63, 64, 65, 73, 78, 82, 84, 85, 89, 92, 93, 97, 98, 99, 101, 103, 111, 113, 121, 123, 126	29, 32, 49, 60, 63, 82, 89, 92, 103, 106	25, 28, 32, 33, 47, 51, 52, 56, 60, 63, 64, 76, 78, 89, 92, 93, 97, 121	3, 11, 14, 15, 20, 23, 25, 26, 29, 35, 54, 56, 57, 63, 64, 67, 73, 76, 85, 92, 100, 101, 111, 123, 126	15, 20, 23, 28, 30, 31, 35, 41, 46, 52, 56, 65, 66, 87, 96, 97, 100, 111, 112, 119, 123, 126
Natural Ecosystem Problems	7, 11, 14, 15, 20, 23, 25, 29, 32, 33, 46, 47, 49, 52, 54, 55, 56, 60, 61, 64, 73, 78, 82, 84, 85, 89, 92, 93, 97, 98, 99, 101, 103, 105, 111, 113, 121, 123, 126	29, 32, 49, 60, 61, 82, 89, 92, 103, 106	25, 28, 32, 33, 47, 51, 52, 56, 60, 61, 64, 76, 78, 89, 92, 93, 97, 105, 121	3, 11, 14, 15, 20, 23, 25, 26, 29, 35, 40, 54, 56, 57, 61, 64, 67, 73, 76, 85, 92, 100, 101, 111, 123, 126	15, 20, 23, 28, 35, 40, 43, 46, 52, 56, 61, 87, 97, 100, 111, 123, 126

APPENDIX B

ADDITIONAL RISK LITERATURE

RISK ANALYSIS

ASSOCIATED REFERENCES

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